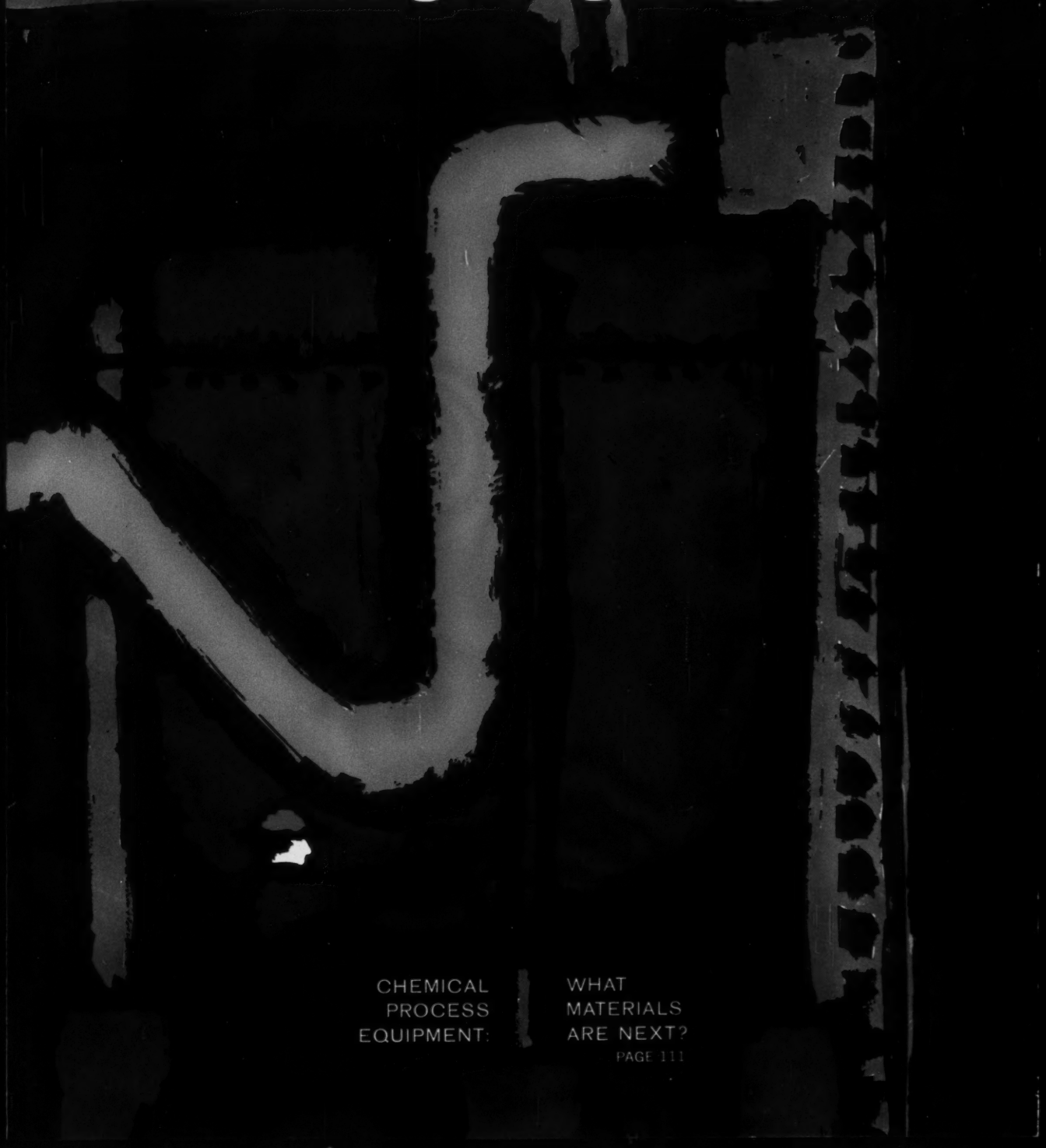
Materials in Design Engineering



CHEMICAL PROCESS EQUIPMENT:

WHAT MATERIALS ARE NEXT?

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Anaconda takes to the road with ideas for greater values and higher productivity

We're in the market with ideas. Ideas for doing new jobs—like making transistor bases and fluid-cooled conductors. Ideas for doing present jobs better—helping you match the metal to the job more precisely so that you can offer equal or greater value *and* reduce total costs.

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We're also busy generating new ideas in an aggressive research and development program. And we plan to make available soon small, balanced value-analysis teams to go out in the field and work with individual company organizations—make specific suggestions and recommendations regarding materials, fabricating methods, design, etc.

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FEBRUARY, 1961 | VOL. 53, NO. 2

Materials in Design Engineering

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

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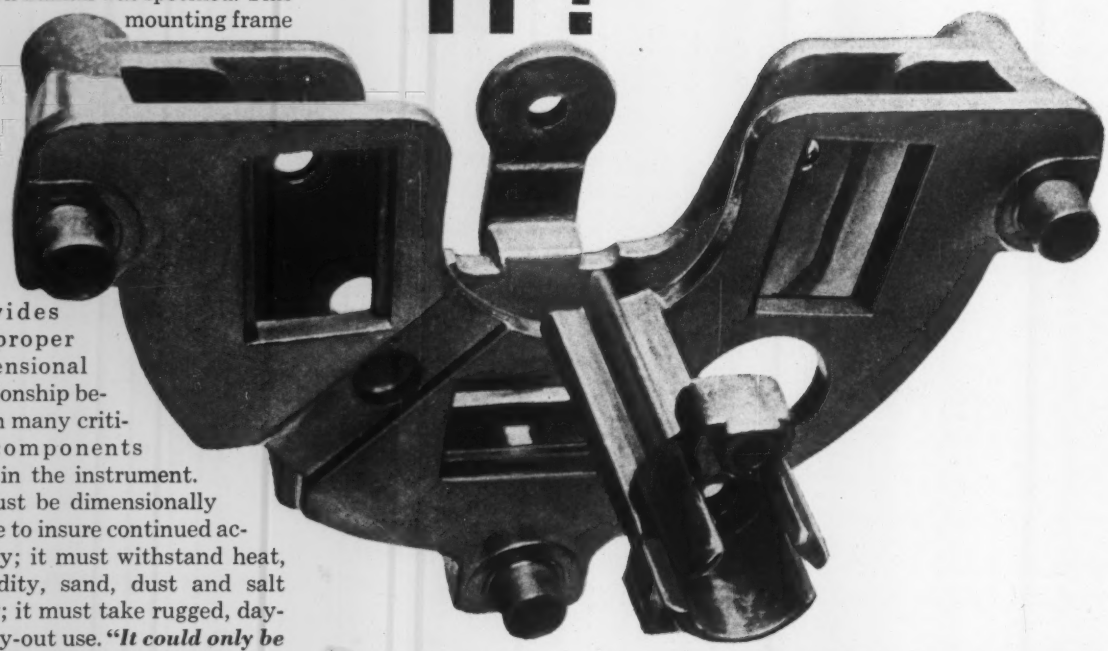
HOW ELSE WOULD YOU MAKE IT?

plus .0005" minus .0000"

These are some of the *cast* tolerances on this complex mounting frame. GE design engineers specified Zamak—"because of the close tolerances we needed and could get... ***without machining.***"

Close tolerances are only one reason Zamak was specified. This mounting frame provides the proper dimensional relationship between many critical components used in the instrument. It must be dimensionally stable to insure continued accuracy; it must withstand heat, humidity, sand, dust and salt spray; it must take rugged, day-in, day-out use. ***"It could only be done in zinc,"*** says the die caster, Peasley Products, Inc.



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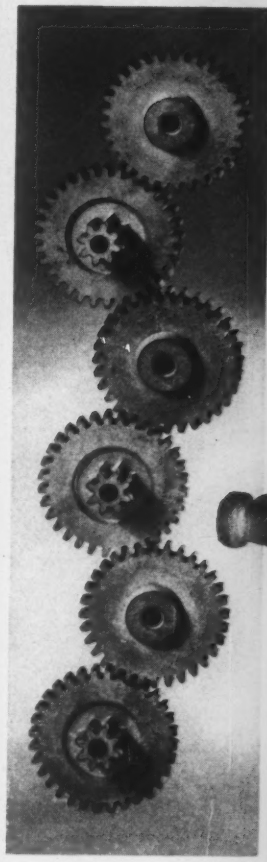
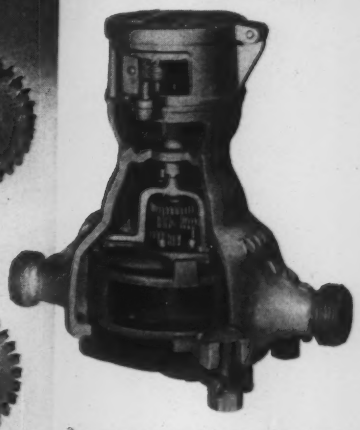
This Month's Cover: *Large scale chemical process equipment. Design and illustration by Harry & Marion Zelenko.*

BRONZE POWDER for GEARS that FIT THE JOB





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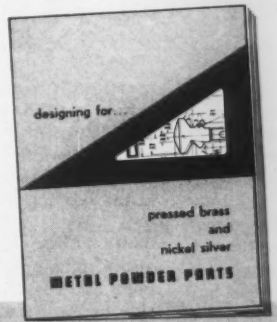
*The PRESMET Corp., Worcester, Mass.



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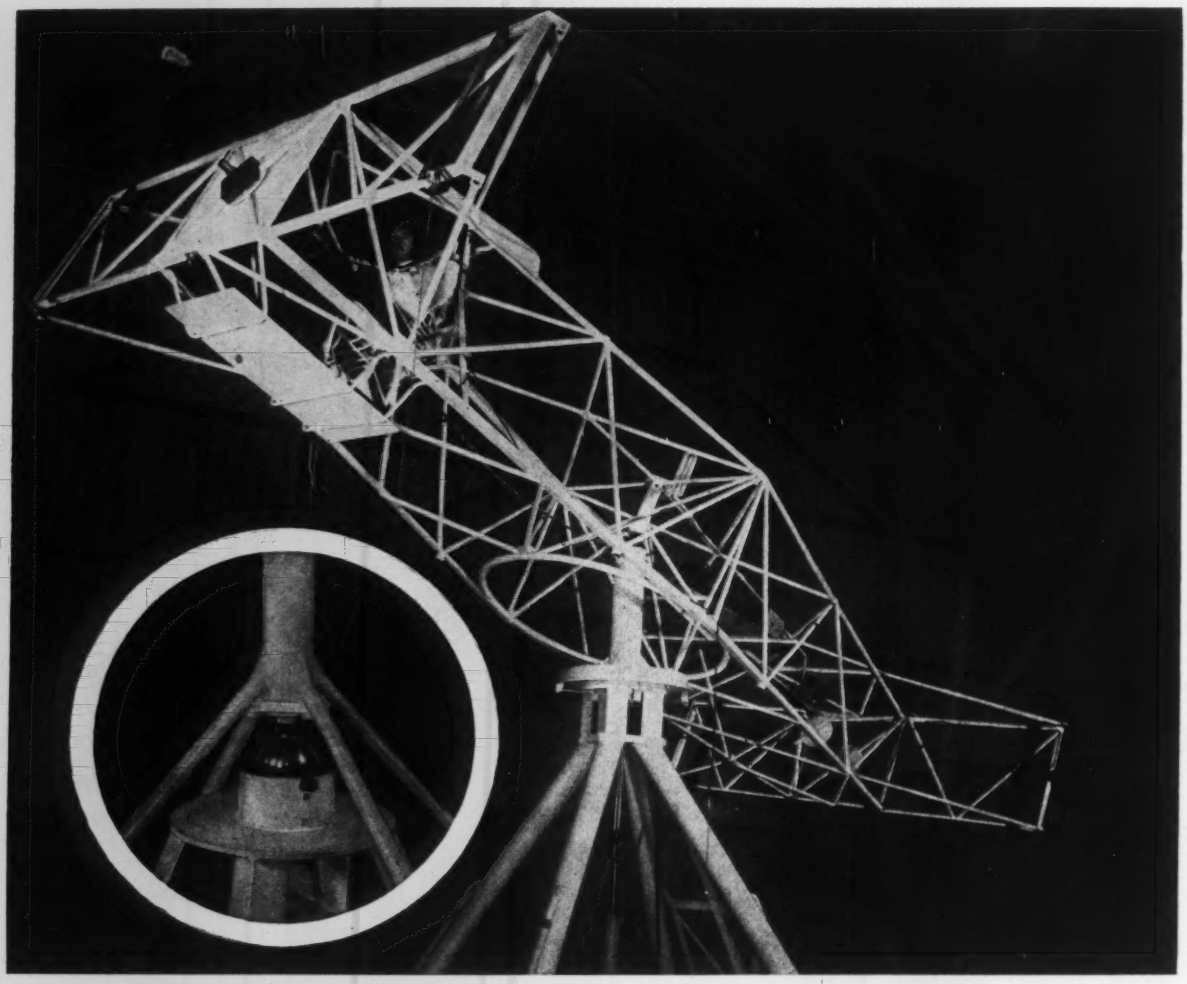

MAKE-BELIEVE FLIGHT—Much of the feeling of flight in a space vehicle is experienced during a ride in this reaction-control simulator, being put through its paces at Boeing Airplane Co., Seattle, Wash. The simulator rides atop the nickel alloy steel ball plated with Nickel in Boeing's ball-and-socket type air bearing.

Space simulator gives the "feel" of flight

Nickel-plated ball of high strength steel supports reaction-control test vehicle

This earthbound space machine is designed to test ways of controlling a vehicle as it pitches, rolls and yaws in the airless reaches of outer space.

In action, the simulator and its payload of test equipment can weigh as much as 5,000 pounds. Yet the necessary sensitivity is achieved by floating the unit on an air-cushion bearing made of a high strength nickel alloy steel ball in its socket.

Imagine this 2½-ton load resting on a ball about the size of a grapefruit! The ball, made of nickel alloy steel heat treated to a tensile strength of 180,000 to 200,000 pounds per square inch, stands up to the load. To provide a hard, smooth surface, the ball is plated with one-thousandth of an inch of Nickel. This uniform surface keeps air leakage in the bearing to a minimum.

Remarkably durable, Nickel and its alloys offer practical solutions to problems of stress, fatigue, abrasion, corrosion or temperature extremes. Used in alloys, in plated coatings or by itself, Nickel helps make possible many new products and processes—and can help improve existing ones—by providing unique combinations of properties.

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What's new IN MATERIALS

...AT A GLANCE

Look for stronger ceramics to come out of present research. For example, it is known that more than one laboratory has produced sintered aluminas having moduli of rupture of 100,000 psi, compared to values of 50,000 psi for currently available aluminas. And work on ductile ceramics will in time result in ceramic parts of usable size that will have permanent ductility, not merely transient ductility under special conditions.

Source: W. M. Sterry, Boeing Airplane Co., Aero-Space Div., Seattle, Wash.

An investment casting method for precision nonferrous parts uses only one disposable pattern made of a low cost mold material and a runner system cast in a single plane. The mold material is said to burn out in one-fourth the time required by conventional molds, and cut-off time for the runners is also reduced. Piece cost is about 50% lower than for other methods.

Source: Atlantic Casting & Engineering Corp., 810 Bloomfield Ave., Clifton, N. J.

New DAP varnishes are said to have excellent resistance to moisture, corrosive gases, fungus and weathering over a wide temperature range. The diallyl phthalates show particular promise for use on capacitors, resistors, transformers, form-wound coils, motor windings, transistors, diodes and similar parts. (More details in a forthcoming issue.)

Source: Food Machinery and Chemical Corp., Chemicals & Plastics Div., 161 E. 42nd St., New York 17.

A clear silicone potting and embedding compound is said to give good mechanical and dielectric protection to electronic parts. A big advantage is that parts embedded in the material can be repaired or replaced by removing a section with a sharp instrument. New material can be poured into the cut-out section and cured to a flexible, resilient solid without leaving evidence of repair. (More details next month.)

Source: General Electric Co., Silicone Products Dept., Waterford, N. Y.

High purity cadmium is now available in the form of bars, rods and shot. Purity is reported to be 99.9999%. The metal sells for $29 per lb in quantities of 5 lb or more.

Source: Semi-Elements Inc., Saxonburg Blvd., Saxonburg, Pa.

An easy way to detect water leaks at high temperatures is to use a new chemical coating compound that changes color when in contact with water. The compound resists heat up to 500 F, as well as air oxidation. It can be applied by brushing or spraying.

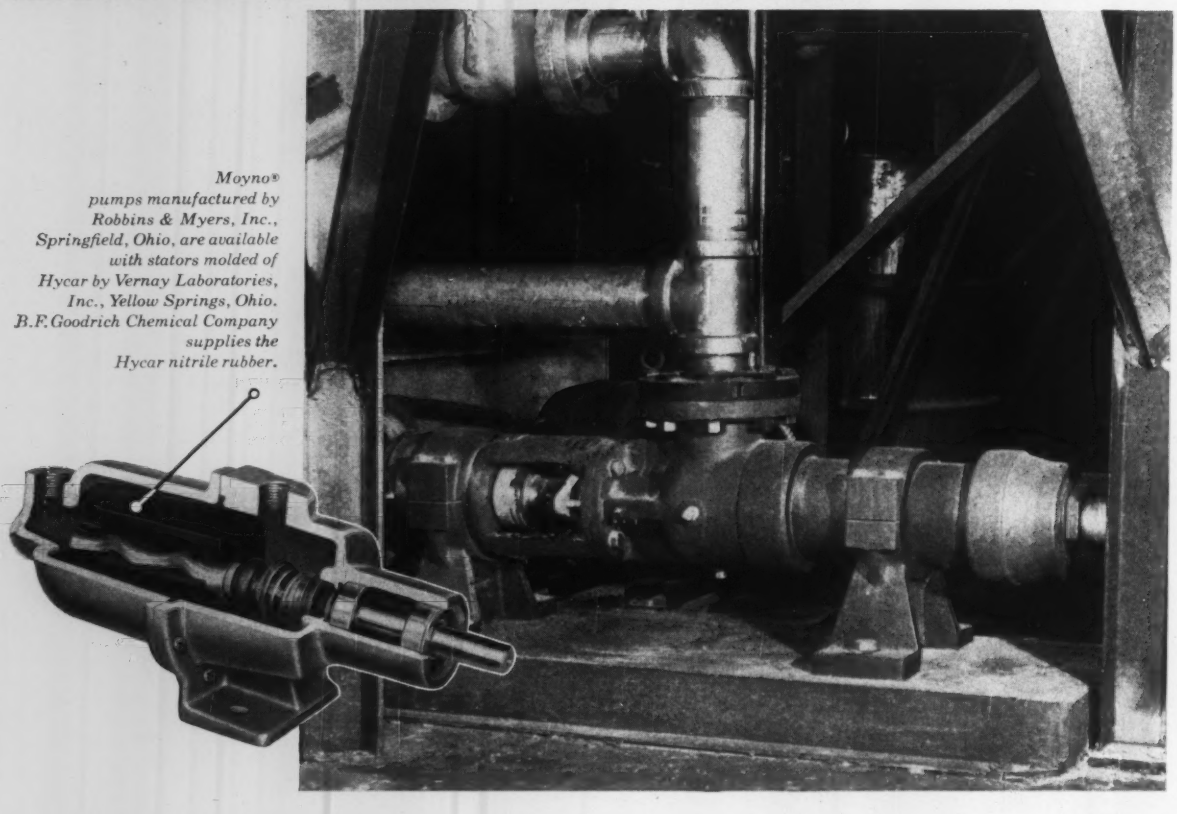
Source: Florence Nesh, National Bureau of Standards, Sound Section, 200 Far West Bldg., Washington 25, D. C.

Injection molding of thermosetting urethane elastomers frees these tough, abrasion resistant materials from the production limitations of previously used liquid casting techniques. The new elastomers will be initially available in hardnesses of Shore D40 to 53. Although some limited success has been achieved in the

Another new development using

B.F.Goodrich Chemical *raw materials*

Moyno® pumps manufactured by Robbins & Myers, Inc., Springfield, Ohio, are available with stators molded of Hycar by Vernay Laboratories, Inc., Yellow Springs, Ohio. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.



STATORS OF HYCAR RUBBER
help pumps handle corrosive jobs

The manufacturer of these pumps says they handle "anything that flows through piping." When the going gets unusually corrosive or abrasive, stators made of Hycar nitrile rubber are used.

The Hycar stators are made in varying hardnesses—rigid for handling some materials, flexible for others. Any corrosive or abrasive material may call for Hycar stators; this pump manufacturer particularly recommends it for petroleum solvents and oils, vegetable oils, alcohols, all salt solutions, mild acids and corrosive liquids.

Hycar gives long-term service in an application like this because of its resistance to chemicals and corrosion that would destroy ordinary rubber. Hycar can be accurately molded into the complex double internal helical design of this pump's stator.

Here's another example of the way that Hycar nitrile rubber helps products find new applications, or helps develop new products. For information, write Dept. MI-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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past in injection molding similar materials, the new elastomers are reported to have injection molding characteristics similar to those of low density polyethylene and polystyrene. Introductory price is expected to be about $1.50 per lb. (More details next month.)

Uranium-containing carbon and low alloy steels are said to have greatly improved fatigue strength, stress corrosion resistance and elevated temperature properties. Development work to date shows the new steels will not cost much more than ordinary carbon and low alloy steels because of the small amount of uranium used. Potential uses: boilers, oil well drilling equipment, marine products and railroad equipment.
Source: Dept. of Mines, Physical Metallurgy Div., Ottawa, Ontario.

Better translucency in reinforced plastics parts is promised with the development of a new fiberglass chopped strand mat that is said to have exceptionally good wetting characteristics. The developer says the material reduces fiber patterns in finished parts, and provides a high degree of translucency for corrugated plastics panels. The mat is supplied in widths up to 76 in.
Source: Pittsburgh Plate Glass Co., Fiber Glass Div., 632 Ft. Duquesne Blvd., Pittsburgh 22.

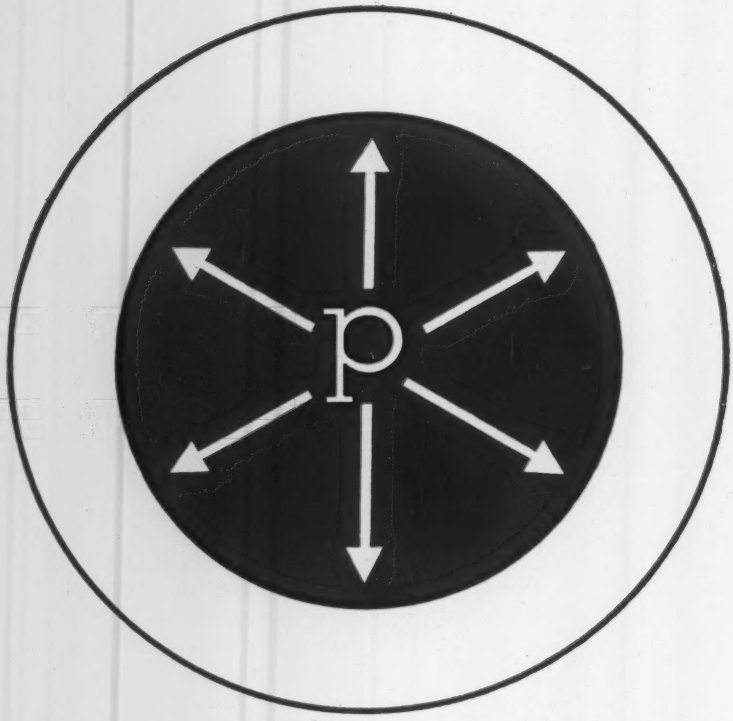
A new diffusion bonding process for copper is said to produce a homogeneous bond that is as strong as, or stronger than, the base metal. Joints are said to retain virtually all of the high electrical and thermal conductivity of copper. Key to the method is a special coating of undisclosed composition that diffuses into the parts to be joined when they are heated in an inert atmosphere at 1700-1800 F. (More details in a forthcoming issue.)
Source: Chase Brass & Copper Co., Waterbury, Conn.

A new woodchip material can be used in place of wood and other engineering materials in applications where a curved or contoured section is desired. The material is a combination of wood chips, chopped fiberglass and polyester resin. It differs from other particle boards in that it is molded at lower pressures, which is said to insure wood fiber quality. The producer says the new material holds nails, tacks, staples and screws better than wood. (More details in a forthcoming issue.)
Source: Gisholt Machine Co., 1245 E. Washington Ave., Madison 10, Wis.

A moldable ceramoplastic for continuous use up to 1200 F has been developed. Earlier grades of these glass-bonded synthetic micas were limited to the 900-1000 F range. In addition to better heat resistance, the new dielectric offers unusually good hermetic sealing characteristics. Seals and commutators appear to be the major potential uses. (More details next month.)
Source: Mycalex Corp. of America, Clifton Blvd., Clifton, N.J.

A new family of bearing steels has been developed. The steels are modifications of type 440C stainless steel, but have improved hot hardness and better resistance to wear, corrosion and oxidation. They are expected to be used in high temperature bearings and structural components.
Source: Latrobe Steel Co., Latrobe, Pa.

Turn to page 9 for more "What's New in Materials"

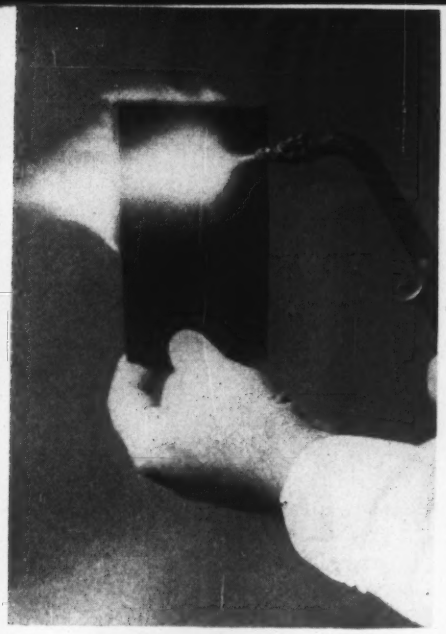


Metallurgical Phenomena... and the metals to cope with them.

These are the stock-in-trade of the Lukens Application Engineer—whether the problem be one of pressure (symbolized above) or corrosion or abrasive impact or structural stress or high and low temperature. Investigation of the best steels for "problem" applications has been carried on for years by the Lukens Application Research team. We would welcome the opportunity to contribute the results of this research to your own design knowledge. Please contact us in your early design stages. Call collect: John D. Heffernan, Manager of Application Engineering, Extension 422, Lukens Steel Company, Coatesville, Pennsylvania. Or write: D21 Services Building.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

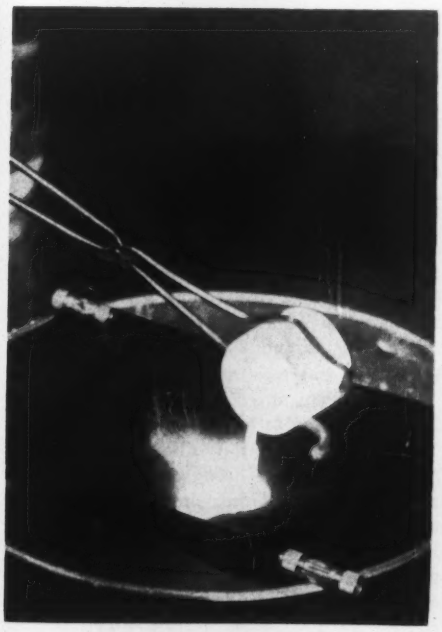
For more information, turn to Reader Service card, circle No. 399



Low thermal conductivity *is demonstrated by man holding 10-ply phenolic laminate made with the new fabric just 3 in. from the point of impingement of 5000 F torch.*

New Organic Fabric Does Not Melt up to 18,000 F

Free of elemental carbon, it is only available in developmental quantities as yet.



Resists molten steel—*A 1-lb slug of molten steel at 3000 F is poured onto a 1-lb-per-sq-yd fabric of Pluton at left. Below, the steel has solidified without charring or melting the material.*

■ A new organic fabric, said to be nonmelting at temperatures up to 18,000 F, has been developed by Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn. The fabric is free of elemental carbon, is electrically nonconductive, and has low thermal conductivity.

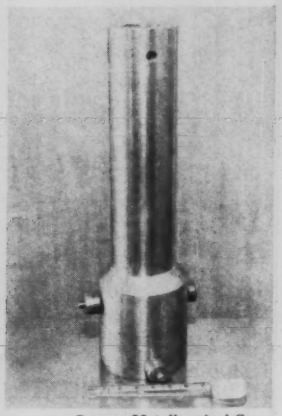
Called Pluton brand heat resistant fiber, the fabric is available in developmental quantities in 5, 8, and 12-oz-per-yd plain weaves. It comes in rolls 12 in. wide and 100 yd long. No price has been announced as yet.

Although the chemical nature of the material has not been disclosed, 3M says that the fibers are composed of molecules containing carbon, hydrogen, oxygen and nitrogen. The material has a specific gravity of 1.45, and a tenacity of 0.8 gm per denier. Electrical resistivity is greater than 100 megohm after 10 min at 1300 F; thermal conductivity is said to be 0.42 Btu/hr/sq ft/°F/in.

Tests to determine acid resistance have been carried out by exposing fabrics to acids for 100 hr at room temperature. The fabric shows negligible strength loss after this degree of exposure to 85% phosphoric acid; 15% loss in strength in hydrochloric acid; and 25% loss in strength in 70% sulfuric acid. Exposure for 100 hr at room temperature to 10% sodium hydroxide embrittles the material, but the fabric can be regenerated by treatment in acid.

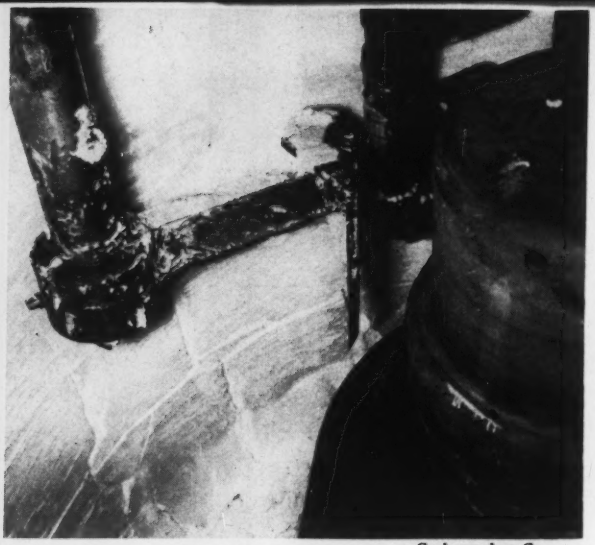
Potential uses for the fabric include reinforcement for high temperature reinforced plastics laminates; insulation for drag-chute compartments in high speed aircraft; anti-arc wraps for electrical power plants; and lightweight fire protective curtains for public buildings, mines and steel mills.

Some current uses . . .



Oregon Metallurgical Corp.
Agitator hub *of zirconium weighs 85 lb, is largest zirconium casting ever made.*

Pfaudler Co.
Sulfuric acid concentrator *uses approximately 700 lb of zirconium.*



Carborundum Co.
Centrifuge plow *is used to cut dried zirconium oxychloride cake from centrifuge basket. Environment: zirconium oxychloride crystal, 6N hydrochloric acid, 95 F. Zirconium plow, still in service after 24 months, replaced the Hastelloy C plow which is shown after one month's service.*

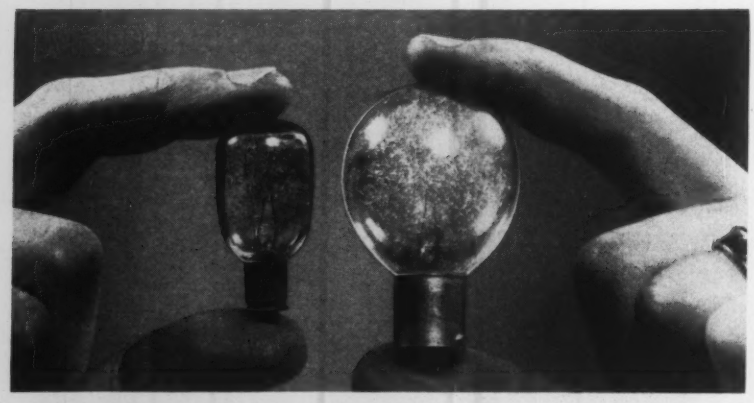
Zirconium Alloys:

Corrosion Resistance and Strength Are Improving

Overshadowed by nuclear applications until now, other industrial uses are beginning to expand. Higher strength alloys are being developed. You should consider zirconium when you need . . .

- *High resistance to acids, alkalis and hot water.*
- *High affinity for oxygen.*

by R. J. Van Thyne, *Armour Research Foundation*



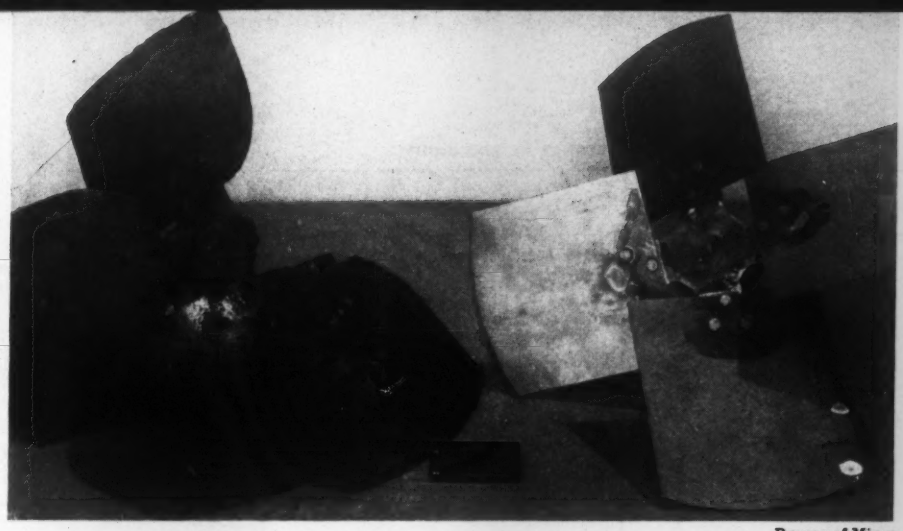
Shredded zirconium foil *in smaller flashbulb produces same light output as larger magnesium foil bulb.*

■ Zirconium is strong, ductile, corrosion resistant and easily fabricated. In the past, the metal and its alloys have been applied in nuclear reactors. The combination of outstanding corrosion resistance to high temperature water, low neutron absorption and generally good engineering properties made zirconium alloys particularly useful in water cooled reactors such as the Shippingport and Yankee installations.

Meanwhile, development of general industrial applications for zirconium has lagged. But recent development of new alloys, together with significant price reductions resulting from expanding production, suggest that greater attention be paid to broadening the applications of zirconium and its alloys, especially in the chemical processing industries.

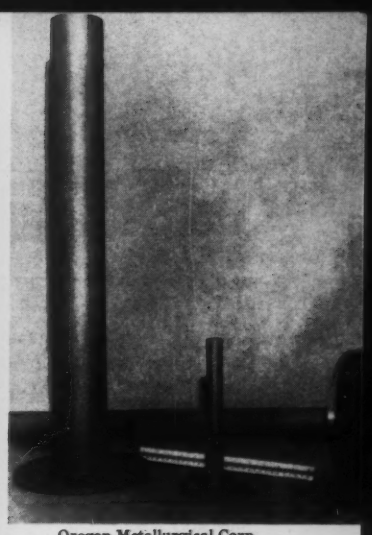
What are the new alloys?

Aside from the Zircaloys (see box) zirconium alloy development has been limited. Many alloy compositions are now being screened with the object of improving strength and corrosion resistance in 600 to 680 F pressurized water and/or 750 to 1000 F steam. Unalloyed zirconium and the Zircaloys do not have satisfactory resistance to high temperature steam, and their strength is undesirably low above 600 F.



Bureau of Mines

Exhaust fan *on left is plastic-coated steel; it failed after eight months of exhausting hydrochloric acid fumes from feed filter press. Zirconium fan on right has been in service for ten months.*



Oregon Metallurgical Corp.

Dip pipe and thermowells *of cast zirconium have excellent corrosion resistance.*

Resistance to carbon dioxide corrosion at temperatures up to 930 F has been obtained by adding ½% each of copper and molybdenum to zirconium. This alloy was developed in Great Britain for use in a gas cooled reactor and is produced in the United States on a license basis.

High temperature strength depends on structure: zirconium transforms from the alpha (low temperature) to the beta (higher temperature) phase at 1585 F. To illustrate the importance of structure: At 930 F, the tensile strength of a zirconium-25% titanium composition was 64,600 psi with an alpha structure. Heating to 1200 F transformed the alpha structure to beta; tensile strength was 4400 psi.

TABLE 1—MECHANICAL PROPERTIES OF SOME HIGH TEMPERATURE ZIRCONIUM ALLOYS AT 1200 F

Alloy Content, %		Ten Str, 1000 psi	Yld Str, 1000 psi[a]	Elong, %[b]
Al	Sn			
2	—	36	29	16
3	—	52	34	10
—	10	47.8	36	19
2	3	50	36	16
3	3	61.4	42	10
Zirconium		5.8	4.7	42
Zircaloy-2		13.2	6.4	21
347 Stainless		51.2	41	60

[a] 0.2% offset. [b] At room temperature.

The metal is significantly strengthened for 1200 F service by additions such as tin and aluminum which stabilize the alpha phase. A few selected data which show the effect of alloy additions

Zircaloys Outstanding in Hot Water

The well-known Zircaloys, containing tin and small amounts of iron, chromium and nickel, have found widespread use in water and steam cooled reactors because of their consistently good corrosion behavior—even in the presence of a moderate amount of impurities. These alloys have been so successful that other zirconium alloy developments have been neglected.

A large quantity of data have been accumulated on the Zircaloys and on rather minor compositional modifications of these dilute tin compositions. At the 1958 Geneva Conference, Russian investigators reported interesting zirconium - columbium and Ozhennite alloys. The latter compositions are essentially modified Zircaloys; i.e., Ozhennite-0.5 contains 0.2% tin and 0.1% each of columbium, iron and nickel by weight.

Properties of the Zircaloys are well-known and need not be detailed here. Ozhennite alloys exhibit a "breakaway" corrosion after long times similar to that of the Zircaloys, i.e., the rate of attack is greatly accelerated after a period of time. Dilute zirconium-columbium alloys corrode at a higher initial rate but accelerated breakaway corrosion does not seem to occur. After 5000 hr in 660 F water, total corrosion is similar to that of Ozhennite.

Pickup of hydrogen during high temperature water and steam corrosion is probably the most important aspect of zirconium technology recently investigated. The absorbed hydrogen may be localized by a thermal gradient and affect mechanical properties to the extent that useful life of a fuel element is limited.

A significant finding has been that the hydrogen absorbed during corrosion may be greatly reduced by alloy content. As a result, compositions such as Zircaloy-4 have been developed in which nickel is present only as an impurity. These alloys pick up only a fraction of the hydrogen that would be absorbed by Zircaloy-2 under similar conditions. Hydrogen limits in zirconium specifications also have been lowered.

TABLE 2—CORROSION RESISTANCE OF ZIRCONIUM

Medium	Conc, wt %	Temp, F	Rating[a]
ACIDS			
Acetic Acid	5-99.5	95-212	AA
Chromic Acid	10-30	95-212	AA
Dichloroacetic Acid	100	95-212	A-B
Formic Acid	10-90	95-212	AA
Hydrobromic Acid	65	95	C-D
Hydrochloric Acid	1-20	225	AA
	20-37[b]	225	A
Hydrofluoric Acid	All	Any	Not rec
Lactic Acid	10-85	95-212	AA
Monochloracetic Acid	100	212	AA
Nitric Acid	10-100	95-212	AA
Nitric Acid, Mixed Fuming	66 white	95	A
Nitric Acid, Red Fuming	—	68-158	AA
Nitric Acid, White Fuming	—	68-158	A
Oxalic Acid	0.5-25	95-212	AA
Phosphoric Acid	5-85	95	A
	5-60	212	A
	60-85	212	B-C
	60-85	410	C-D
Sulfuric Acid	10-70	95	A
	10-40	212	A
	80-96	95-212	Not rec
Sulfurous Acid	6	212	A
Tartaric Acid	10-50	95-212	AA
Trichloroacetic Acid	100	212	AA
MISCELLANEOUS CHLORIDES			
Aluminum Chloride	1-30	95 Boil	AA
Ammonium Chloride	1-Sat	95-212	AA
Aniline Hydrochloride	5-20	95-212	A
Barium Chloride	5-20	95-212	A
Calcium Chloride	10-65	68-212	AA
Calcium Hypochlorite	5-25	95-212	AA
Carbon Tetrachloride	50-100	95-212	AA
Chlorine Gas (dry)	—	—	A
Chlorine Gas (wet)	—	77	Not rec
Chlorine Saturated Water	—	RT	AA
Cupric Chloride	1	95-140	A
	Over 1	95-212	C-D
Ethylene Dichloride	50	Boiling	AA
Ferric Chloride	1-5	95-140	A
	5-15	212	C
	Over 15	95	D
Mercuric Chloride	1-Sat	95-212	AA
Nickel Chloride	5-20	95-212	AA
Sodium Chloride	3-Sat	95-212	AA
Sodium Hypochlorite	0.5	95-212	AA
Stannic Chloride	5-25	95-212	AA
Stannous Chloride	15-75	95-212	A
Substitute Sea Water	—	95-212	AA
Tetrachloroethylene	50	Boil	AA
Trichloroethylene	50	Boil	AA
ALKALIS			
Alum	To 90	95-Boil	A
Ammonia	30	95	AA
Ammonium Hydroxide	28-40	95-212	AA
Magnesium Carbonate	5	212	A
Potassium Hydroxide	10-40	95-212	AA
Sodium Hydroxide	10-73	95-212	AA
OTHERS			
Acetic Anhydride	99.5	Boil	A
Aqua Regia	Conc	68-176	C-D
Carbon Dioxide	—	932	A
Chloroform	50	Boil	AA
Ethyl Alcohol	95	Boil	A
Hydrogen Peroxide	10-70	95	A
Lithium	—	482	AA
Mercury	—	194	D
Methyl Alcohol	99	Boil	A
Silver Nitrate	0.8	68	A
Sodium	—	932	AA
Urea	—	374	A

[a]Rating: AA = less than 1 mpy; A = 1 to 5 mpy; B = 5 to 10 mpy; C = 10 to 25 mpy; D = Over 25 mpy.
[b]Sealed container.
Source: Carborundum Metals Co.

on 1200 F strength are presented in Table 1. A number of alloys showed yield strengths over 20,000 psi at 1470 F. The zirconium-10% tin alloy exhibited yield and ultimate tensile strengths of 24,000 and 27,700 psi respectively.

New alloys such as these should broaden the industrial possibilities of zirconium. Because a limited market and limited availability have not encouraged alloy developments for non-nuclear applications in the past, most current uses outside the reactor field are limited to commercial-grade zirconium which contains 2% hafnium. Chemically hafnium is closely related to zirconium and the small addition has little effect on properties.

Great potential in chemical processing equipment

The chemical processing industries will gain a great deal from the use of zirconium. Except for tantalum, it is unexcelled in its corrosion resistance to many chemicals (see Table 2). In some cases, zirconium may replace tantalum on the basis of lower cost and provide better service than a less expensive material such as stainless steel or titanium.

Zirconium resists both acids and alkalis (see M/DE, Jan '60, p 102). Resistance to hydrochloric acid is outstanding: in boiling 20% hydrochloric acid the corrosion rate is 0.1 mpy (mils per year) initially, though it increases to several mpy after hundreds or thousands of hours exposure. Zirconium is also superior to titanium in these environments: many concentrations of sulfuric and nitric acid; phosphoric, formic and oxalic acids; aluminum chloride; and fused caustic soda. Use of zirconium in sulfuric acid stems from its resistance to stronger concentrations and its ability to withstand both oxidizing and reducing conditions.

Although titanium is generally applied in oxidizing environments, zirconium has superior corrosion resistance in concentrated hydrogen peroxide. Zirconium is less resistant than titanium to aqua regia, ferric chloride and wet chlorine gas.

Practical applications in the

chemical industry include heat exchangers, containers, impellers, and valve and pump parts.

As an example, a 6-in. dia cast zirconium impeller was used at room temperature in a solution containing hydrochloric acid, zirconyl chloride, thiocyanic acid, 500 ppm iron and some ketone solvent; after one year the impeller was checked and a 10-year service life was estimated.

Other specific applications: Zirconium valves have worked well in replacing glass lined valves for acid service where breakage has been a problem. Spinnerettes employed in rayon fiber production resist both acid and alkaline solutions. Deep drawn zirconium analytical crucibles are sold for peroxide and carbonate fusions.

Use in getters increasing

Affinity for oxygen and nitrogen at elevated temperatures accounts for use of zirconium as a getter material. More than two tons of zirconium foil was used in "hot traps" to absorb oxygen from the sodium coolant of the Dounreay reactor in Scotland. Since zirconium was employed outside the reactor, the hafnium-bearing commercial grade was satisfactory.

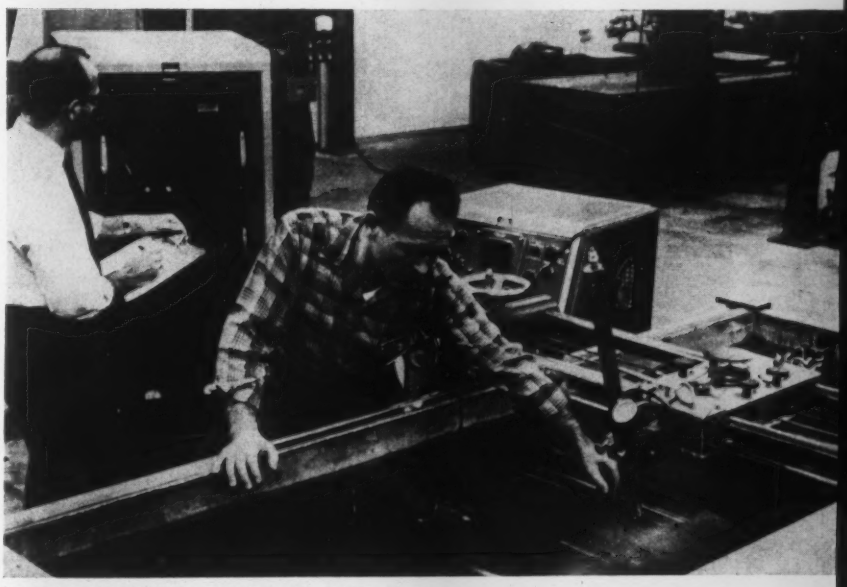
Shredded zirconium foil or wire in flashbulbs provides a brighter flash than magnesium foil since it oxidizes more efficiently, allows higher initial bulb pressure because a lower pressure is created during the flash, and burns cleaner, blackening the bulb less. Use of zirconium for this application has greatly increased.

Other specialized uses may be found. Two examples: glass-to-metal seals and surgical implants.

Large Plastics Moldings OK'd by Ultrasonic Inspection

Here is the first report on ultrasonic testing of massive compression molded parts. It is a rapid, reliable and economical way to check critical moldings.

by J. M. Kramer, A. F. Nuzzo, Jr., and G. Epstein,
Structural Materials Div., Aerojet-General Corp.



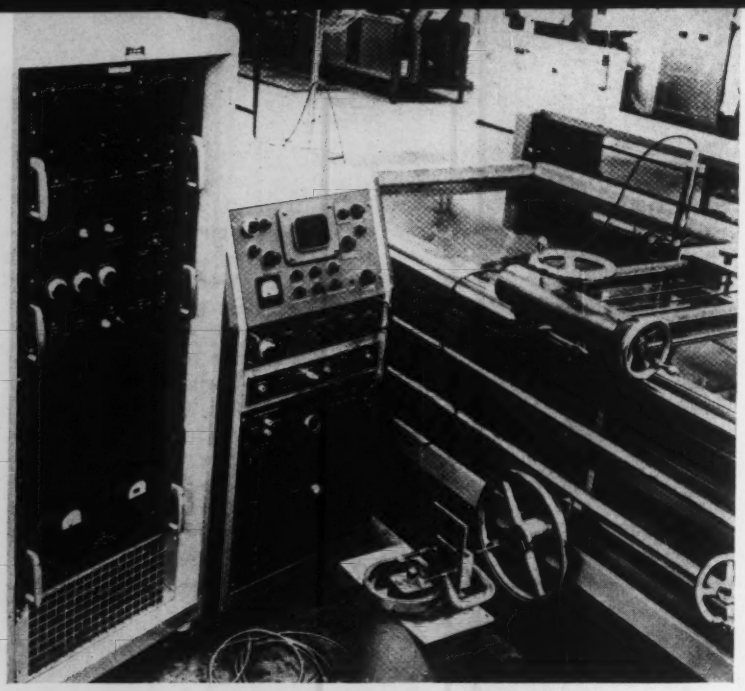
***Marking defective areas** located by sound wave.*

■ Success in using ultrasonic inspection of large reinforced plastics moldings has resulted in economies in three ways: 1) rejection of defective parts prior to use, 2) elimination of defective billets prior to machining, and 3) improvements in fabrication techniques.

Ultrasonic testing can be used to detect location, size and orientation of voids, cracks, resin-rich or resin-starved areas, or any other anomaly within the part which changes the velocity, direction or intensity of the ultrasound.

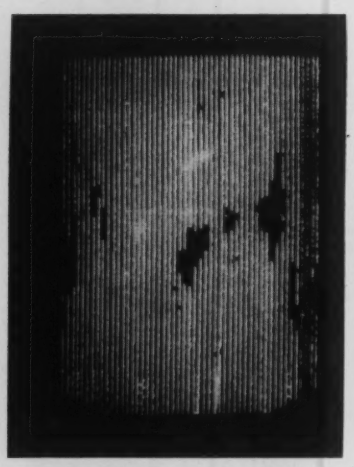
In the past, ultrasonics have been used economically for testing industrial thermosetting laminates. But attempts to use the technique for massive moldings have met with little or no success. High attenuation and scattering of the ultrasound within the plastic has caused difficulty in receiving any information, much less meaningfully interpreting these data.

The success now achieved by the Special Projects Group of



1 ***Equipment*** *consists of (l to r) Soltronics-Sonafax Model SR-100, Sperry Reflectoscope Model UW and Ultrasonic Development Tank.*

Three techniques . . .



2 ***Pulse echo*** *methods produce this typical inspection record showing defects as dark areas.*

3 ***Through transmission*** *must be used on parts as thick as this entrance nozzle billet.*

4 ***Shear wave*** *methods must be used on complex shapes such as the rocket entrance nozzle at left and exit cone at right.*

Aerojet-General is due to close cooperation with equipment and component suppliers in developing specialized equipment and testing techniques. Equipment used for this program consists of a Sperry Reflectoscope Model UW, and a Soltronics Sonafax Model SR-100. The former unit is essentially an ultrasonic flaw detector; the latter unit contains a memory tube which can "draw" a picture of the flaw areas. The two units and the ultrasonic immersion testing tank are shown in Fig 1.

Technique depends on size and shape of part

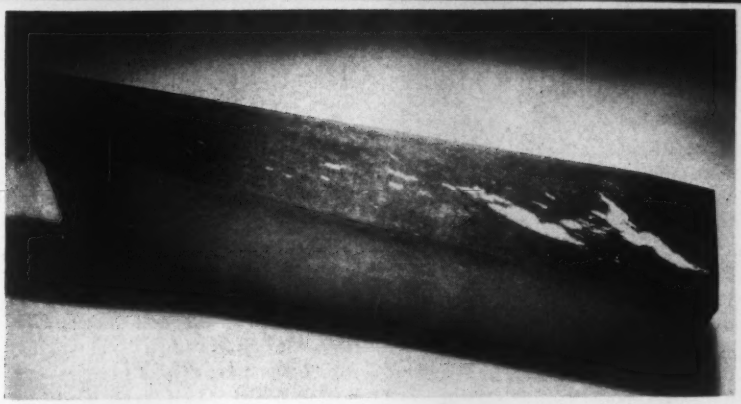
Three basic test techniques can be used, depending on the size and shape of the part to be tested. The availability of the three techniques permits effective testing of virtually any size and shape of part.

The three techniques:

1. *Pulse-echo* method is used for parts up to about 5 in. in thickness. The part is immersed in the test tank with its surface perpendicular to the direction of the ultrasonic pulse produced by the transducer. Ultrasound is sent through the part and is reflected back to the transducer by the back surface of the part. The intensity of the echo is monitored by the Sonafax unit.

When the ultrasound wave encounters a defect the intensity of the back-surface echo is reduced and the memory tube of the Sonafax unit records the change in intensity as a dark spot. Progressive scanning of the part produces a two-dimensional picture in which defects are represented as dark areas while defect-free areas appear light. A typical "picture" is shown in Fig 2.

2. *Through transmission* is used for parts thicker than about 5 in. but of generally regular configuration. The intensity of a beam of ultrasound decreases approximately 80% in passing through an interface. Further attenuation occurs as the sound travels through the plastic part. If the part is thicker than about 5 in. the intensity of the echo is



5 ***Fluorescent dye*** *(Zyglo) method shows defects to be where ultrasonic testing indicated.*

6 ***Typical exit cone*** *with marked defective areas indicated by shear-wave inspection.*

too low for reliable detection.

For through-transmission testing, two transducers are placed on opposite sides of the part to be inspected. One transducer is used to send the ultrasonic signal; the second transducer acts as the signal receiver. The sound only travels once through the part. Typical of the type of parts inspected by through-transmission techniques is the rocket entrance nozzle billet shown in Fig 3.

3. *Shear-wave* technique is used for testing complex shapes such as the rocket entrance nozzle and nozzle exit cone shown in Fig 4. The shapes of these parts do not easily lend themselves to either pulse-echo or through-transmission testing.

In shear-wave testing a signal is sent into the part at an angle ranging from 17½ to 30 deg from the normal. If no defects are present the sound is simply reflected between the surfaces of the part until attenuated. Thus no signal returns to the point of origin.

Any defect present will reflect the signal and an echo will be detected by the transducer.

Tests bear out techniques

The accuracy and reliability of ultrasonic testing has been verified at Aerojet-General by a number of tests. For example, a molded plastic rocket nozzle exit cone was inspected ultrasonically and several apparently severe defects were precisely located. The part was machined to expose these defects and then visually inspected by fluorescent dye (Zyglo) techniques. Fig 5 shows the revealed cracks which were in the precise location predicted by ultrasonic inspection.

In another test, 15 molded rocket nozzle exit cones received from a vendor were inspected ultrasonically by a modified shear-wave technique. Although the acoustical properties of the material had been determined, no reference standard with intentional defects was available. Several parts were inspected to establish an arbitrary rejection level. Areas were marked defective if a 90% decrease in ultrasonic transmission occurred, since this decrease had been found to be characteristic of parts containing large radial cracks.

Fig 6 shows one of the parts with the defective areas outlined. Ultrasonic testing indicated that the defects were oriented at a 45-deg inclination to the longitudinal axis of the part. Fig 7

How About Radiography?

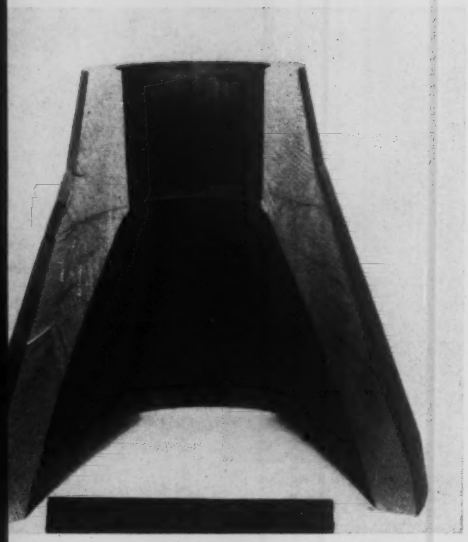
In developing nondestructive test methods for large compression moldings, radiographic inspection methods were also evaluated. Ultrasonic methods proved to be more rapid, reliable and economical than radiography. An important limitation of radiography was that although large cracks were readily detected, smaller cracks could be made out only with extreme difficulty.

In radiographic inspection the part is exposed to x-radiation, and the amount of radiation passing through the part is recorded on photographic film. A density profile results.

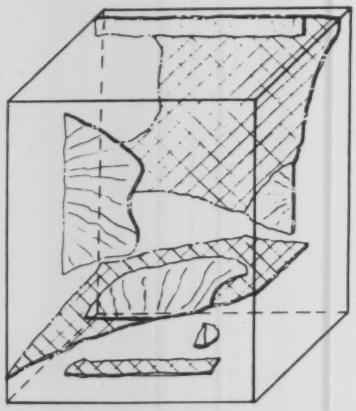
An example

In evaluating radiography, a hollow truncated cone was inspected. Since no experience had been accumulated on the transmission of radiation through this particular part, exposures were made at several power settings. The clearest density profile obtained is shown in the accompanying photo.

The large, dark area in the center shows the hollow inner portion. The two large light areas represent the sides of the part. Small light areas marked with circles (difficult to make out in the photo as reproduced for publication) are caused by the presence of high density inclusions which allow less radiation to penetrate to the film. Cracks or voids would normally appear as dark areas, but none is visible.



7 Exit cone *shown in Fig 6 has been sectioned, revealing radial defects in areas indicated by ultrasonic inspection.*



8 Thermal shock test *results are sketched here. Wavy-lined areas indicate defects prior to thermal shock; crosshatched areas indicate defects caused by thermal shock. Both defects were detected by ultrasonic inspection.*

shows the part sectioned to verify the validity of the inspection technique. The large radial cracks shown in the wall are exactly as predicted by ultrasonic inspection.

Results show need for improved fabrication

Ultrasonic test results can be useful in indicating the need for altering or modifying molding or fabricating techniques. For example, of the 15 molded exit cones mentioned above, 13 were found by ultrasonic inspection to have subsurface defects over 60 to 80% of the conical area. The majority of these defects were in the central section of the cone. The occurrence of such defects in these particular areas of the part was considered to be caused by certain inadequacies in molding procedures. When this situation was reported to the fabricator, he modified his molding techniques to eliminate or minimize recurrence of such defects.

In another case, several movable nozzle exit cones were found by ultrasonic inspection to contain defects 3-4 in. above the base of the part. The fabrication procedure was reviewed and the molding cycle altered accordingly. Subsequent parts contained markedly fewer and smaller defects as determined by ultrasonic inspection.

Evaluating effects of service conditions

Ultrasonic testing has been found to be invaluable for rapid, nondestructive determination of the effects of exposure to simulated service conditions on parts. Correlating the effects of such conditions with results of ultrasonic tests can also lead to establishment of acceptance criteria for parts.

Mechanical shock—In a mechanical shock evaluation, a molded nozzle exit cone was inspected ultrasonically and the size, shape and position of defects carefully noted. The part was then dropped 10 ft on its inlet section and inspected ultrasonically. Finally it was dropped 40 ft on its inlet section and again tested ultrasonically.

Results showed that no new cracks or growth in the size of the original defects occurred. Consequently, ultrasonic testing permitted us to conclude that mechanical shock did not cause crack formation or propagation in this particular part.

Thermal shock—A 3 × 3 × 2-in. rectangular molded block was carefully inspected using the pulse-echo technique. The size, shape and position of three major flaws were precisely determined. The block was heated to 400 F in 80 sec using a dielectric preheater. It was then reinspected ultrasonically.

Fig 8 is a schematic drawing of the effects of thermal shock. The three original flaws (shown by the wavy lines) had become enlarged to form two large, continuous cracks (shown by cross-hatching). A new flaw was located in an apparently defect-free area.

In subsequent thermal shock tests, small machined plastic tubes were exposed to thermal shock by inductively heating a steel pipe running through the center of the tubes to a temperature of about 2000 F within a few seconds. This method more nearly reproduces the thermal conditions encountered in a rocket component.

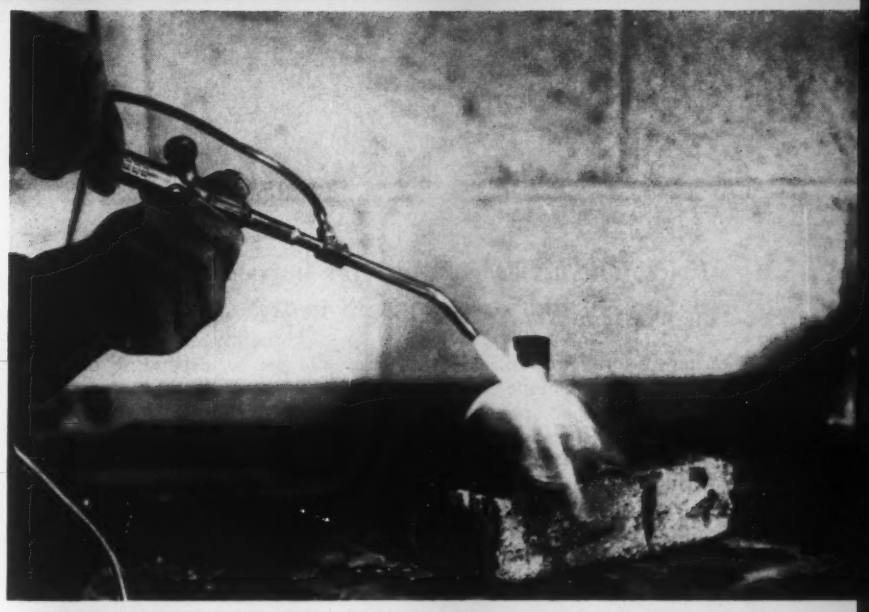
Needed: standards

There is still a great deal of work to be done in developing adequate acceptance and rejection standards for ultrasonic testing of reinforced plastics moldings. Inspection techniques must differentiate between defects that would impair performance of the part and those that would not. No reference standard is presently available, and only limited data exist correlating effects of service environments with results of ultrasonic inspection.

Aerojet-General has now ultrasonically inspected more than 400 compression molded reinforced plastic rocket components of a variety of configurations. At present, parts that are rejected are sectioned and the defects are correlated with the initial ultrasonic inspection record. We are now attempting to establish test procedures for production parts, continuing to develop and refine ultrasonic inspection techniques, and accumulating test data that will lead to satisfactory quality control and assure maximum reliability.

Acknowledgment

The authors wish to acknowledge the assistance provided by various personnel at Aerojet-General Corp., especially W. A. Miller, P. A. Fordham and L. S. Halsema.



***Accurate brazing** is an important advantage of new process. Item being brazed here is base joint of a tubular leg for office typewriter desk.*

New Surfacing Process Uses Oxyacetylene Flame

■ A new surfacing process designed especially for hardfacing and brazing offers a high degree of versatility combined with low cost. Known as Aircospray and developed by Air Reduction Sales Co., 150 East 42 St., New York 17, the process for the first time permits powdered metals to be sprayed and fused on to a base metal by means of an oxyacetylene flame.

Process well suited for hardsurfacing and brazing

In addition to a wide range of silver brazing alloys, the new process can be used to deposit many hardfacing alloys including the cobalt and iron-base high chromium alloys. Hardfacing with powder instead of rod offers two important advantages:

1. The alloys have greater hardness when they are deposited from powders.

2. A powdered metal with a high melting point can be deposited on a base metal with a lower melting point.

In the oxyacetylene process, surface temperatures during application are relatively low because the flame, although quite hot itself, only contacts the surface for a brief period. Thus, the process works just as well on thin light structures as it does on heavier sections.

Typical hardsurfacing applications that have been suggested for the new process are pistons, valves, saw blade guides as well as other sliding surfaces on engines, pumps and farm machinery.

When used with phosphorus or silver filler metals, the Aircospray process provides true capillary (deep penetration) brazing. The process also permits accurate placement of the filler metal, combined with flux, directly on the joint. Thus it is expected to be especially useful in fabricating metal office furniture and in making sanitary joints for hospital furniture.

How it works

Heart of the new process is a standard oxyacetylene welding outfit with a modified torch tip which permits the powdered metal to be sprayed through the oxyacetylene flame. In addition, a carrier gas such as argon, helium, nitrogen or carbon dioxide and necessary controls are required to dispense and carry the powdered metal to the torch tip. The fuel gas can be either acetylene or natural gas.

In operation, the specially designed tip permits simultaneous passage of the oxygen-fuel mixture and the powdered metal into the flame. Two separate channels in the tip eliminate the costly and bothersome problem of flashback. This tip arrangement enables the metal particles to be dispersed into the center of the flame for good deposition.

Smooth, thin coatings

Because the powdered metal is steadily controlled during application, it is claimed that hardfacings and brazed joints are smoother than those produced by other methods. Airco also says that, because of its exclusive vibrator and flowmeter control and the low flow rate of carrier gas (about 5 to 8 cu ft per hr), it has eliminated any possibility of caking and turbulence.

The fineness and uniform deposition of the metal powders permits application of thin (as low as 3 mils) coatings. This close control can provide cost savings over conventional spraying processes which may require grinding to bring a part down to its required size.

New ABS Plastics Offer Lower

Price falls between ranges for impact polystyrenes and existing ABS materials.

■ A new family of ABS plastics (acrylonitrile - butadiene - styrene) has been developed, pegged at a semicommercial price of 37-49¢ per lb for natural color in volume quantities. Prices of other commercial ABS materials start at 47 or 49¢ per lb, depending on type. The apparent aim of the new family of materials is to fill the gap between the 20-30¢-per-lb impact polystyrenes and the higher priced ABS grades.

Developed by Monsanto Chemical Co., Plastics Div., Springfield, Mass., and tradenamed Lustran I, the materials are available in both molding and extrusion grades. They are said to provide the combination of toughness, rigidity, strength and colorability common to other ABS materials, coupled with improved thermal stability for better processing.

Currently available in limited

HOW NEW ABS PLASTICS COMPARE WITH OTHER THERMOPLASTICS

Material →		Commercial ABS Resins[a]		Lustran I (ABS)			Impact Polystyrenes	
		Medium Impact[a]	High Impact[f]	288-1 (Molding)	288-3 (Molding)	288-2 (Extrusion)	Medium to High Impact	Extra High Impact
MECHANICAL PROPERTIES	ASTM							
Izod Impact Str, (73 F) ft-lb/in. notch[b]	D256	1.5	3–6	3.5	2.5		0.6-3.0	6–9
Tensile Yield Strength, 1000 psi	D638	8.8	5.5	6.5	8.0	5.3	3.5-6.8	3.0-4.5
Ultimate Elongation	D638	20	—	70	40	30	5–35	30–40
Tensile Modulus of Elasticity, 10^5 psi	D638	4.0	2.9	3.3	3.8	2.9	3.0-4.5	2.5-2.8
Flexural Strength, 1000 psi	D790	13.5	7.5-10	9.5	12.5	8.6	No break	No break
Flexural Modulus of Elasticity, 10^5 psi	D790	4.5	2.5-3.2	3.6	4.4	3.3	3-5	2.5-3.0
Rockwell Hardness	D785	R118	R92-105	R102	R104	R100	M15-80	—
Deformation under Load (122 F, 2000 psi, 24 hr), %	D621	0.5	0.8	2.0	0.9	—	—	—
PHYSICAL PROPERTIES								
Specific Gravity[c]		1.07	1.04	1.04	1.04	1.04	1.04-1.08	1.05
Mean Density, lb/cu in		0.039	0.037	0.037	0.037	0.037	0.038	0.038
Heat Distortion Temp, F[d]								
66 Psi	D648	215	213	—	—	—	—	182-185
264 Psi	D648	200-230	185-198	175[g]	177[g]	185	155-190	155-180
Water Absorption (24 hr), %	D570	0.3	0.2	0.3	0.3	0.2	0.04-0.08	0.05-0.20
Coef of Ther Exp, 10^5 per °F	D696	3.2	5.5-5.6	—	—	—	3.3-4.7	4.2-5.6
Ther Cond, Btu/hr/sq ft/°F/in	C177	1.8	1.5-2	—	—	—	0.3-0.9	0.3-0.9
Flammability (0.050 in. thick), ipm	D635	1.3	1.3	1-2	1-2	1.2	0.5-2.0	0.5-2.0
ELECTRICAL PROPERTIES								
Dielec Str (short time), v/mil	D149	385	350-400	518	515	456	450	300-650
Volume Resistivity, ohm-cm	D257	2.7×10^{16}	$1-8 \times 10^{13}$	4.2×10^{15}	6.5×10^{15}	1.0×10^{17}	10^{14}-10^{16}	10^{12}-10^{17}
Dielectric Constant								
60 Cps	D150	3.1	2.9-4.2	—	—	—	2.5-2.7	2.5-4.0
10^3 Cps	D150	3.1	2.9-4.2	2.87	2.89	2.92	—	2.5-4.0
10^6 Cps	D150	3.0	2.4-3.6	2.82	2.88	2.85	—	2.5-4.0
Dissipation Factor								
60 Cps	D150	0.004	0.009-0.015	—	—	—	0.0007-0.008	0.003-0.14
10^3 Cps	D150	0.005	0.002	0.006	0.007	0.006	0.001-0.010	0.003-0.16
10^6 Cps	D150	0.010	0.026	0.009	0.008	0.008	0.001-0.010	0.003-0.16
Arc Resistance, sec	D618	70-80	70-80	—	—	—	—	—
COST								
Cents per Cu In		1.9	1.9	1.9	1.5	1.9	1.2-1.7	
Cents per Lb		47	49	49	41	49	25-40	

[a]The "medium impact" and "high impact" types ABS are shown here because the new ABS materials compare most closely with these grades. Other commercial grades of ABS available include Extra-High Impact, Low Temperature Impact, and Heat Resistant.
[b]Values obtained on ⅛ x ½-in. specimens.
[c]Values are for natural color; pigments in color compounds vary specific gravity.
[d]Values given for commercial ABS materials cover range obtained on both injection and compression molded specimens. Highest values are generally for compression molded specimens.
[e]General range obtainable in Naugatuck Chemical's Kralastic MM.
[f]General range obtainable in Kralastic F and MH, and Marbon Chemical's Cycolac T.
[g]Values obtained on unannealed specimens; annealed values are 195 and 197 F for 288-1 and 288-2, respectively.
[h]At 4000 psi.
[i]Values obtained on unannealed specimens; annealed value is 206-208F.

Cost, Better Processing

quantities, the new resins are expected to be in full production by the last half of the year.

Table compares properties

The accompanying table compares properties of the new materials with those of the two types of available ABS materials whose properties are most similar to those of the newer materials. Property ranges for impact polystyrenes are also given for comparison.

Another type of ABS, not shown in the table but also available, according to Monsanto, is Lustran I, 288-5. This material is priced at 37¢ per lb in natural color and volume quantities. Although property data are incomplete, the material is said to have a tensile strength of 9500 psi, tensile modulus of 450,000 psi, ultimate elongation of 10%, and an Izod impact strength on a ½ x ½ in. specimen of 0.8-1 ft-lb per in. notch. Heat distortion temperature under 264 psi stress is 185 F unannealed. The properties appear to make the material most competitive with the Medium Impact ABS shown in the table.

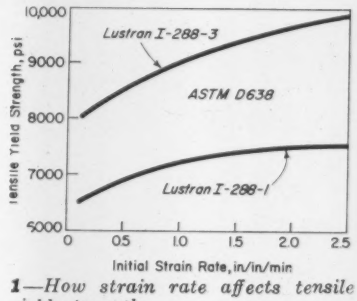
How the new ABS perform

As the accompanying table shows, properties of the new ABS materials coincide with or fall between those of so-called medium impact (Kralastic MM) and high impact (Kralastic MH and Cycolac T) ABS materials. (For complete details on ABS plastics see "ABS Plastics Are Low Cost, Tough, Resistant, Moldable," July '60.)

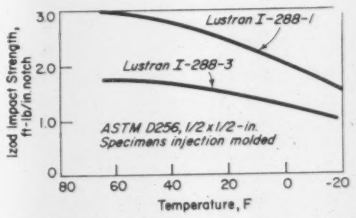
Tensile strength of the materials is relatively high. Values given in the table were obtained at relatively low strain rates; Fig 1 shows the increased tensile yield strength obtained at higher strain rates. Since the stress-strain curves for ABS materials peak at the yield point and failure occurs subsequently at lower stresses, yield strengths are more meaningful than ultimate tensile strengths.

Impact strength is relatively high, and as shown in Fig 2, remains at 1 or more ft-lb per in. notch at temperatures as low as —20 F.

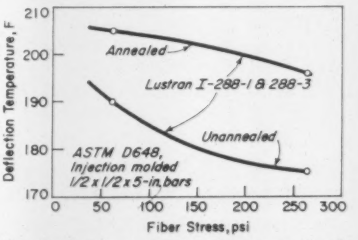
Heat resistance, at best a difficult property to measure meaningfully by standard tests, is indicated by deflection temperatures shown in Fig 3. These values were obtained by ASTM D648 at a range of fiber stresses. Commonly reported values from this test method are deflection temperatures (heat distortion points) at 66 and 264 psi fiber stress. De-



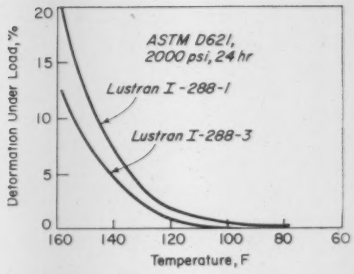
1—*How strain rate affects tensile yield strength.*



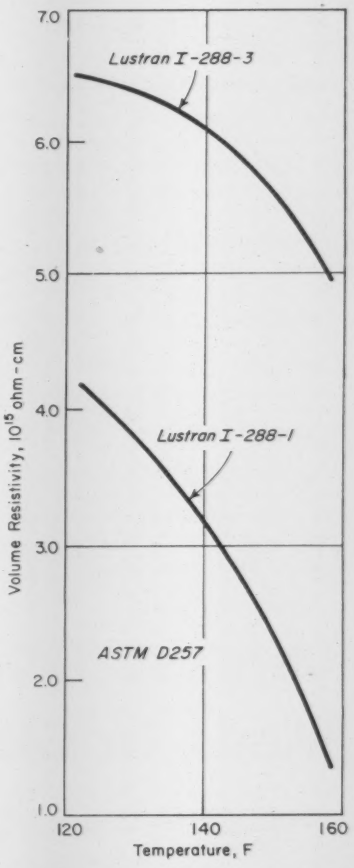
2—*Effect of temperature on impact strength. Note that data were obtained on ½ x ½-in. specimens. Values for these are lower than values for ½ x ⅛-in. specimens used for data in table.*



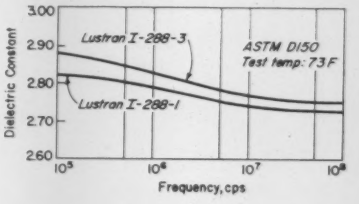
3—*Deflection temperature vs load. Commonly reported values for heat distortion temperatures are those obtained at 66 and 264 psi fiber stress.*



4—*How temperature affects compressive deformation under load.*



5—*Effect of temperature on volume resistivity.*



6—*Effect of frequency on dielectric constant.*

formation under load vs temperature is shown in Fig 4.

Electrical properties are good—comparable to those of other ABS materials (see Fig 5 and 6).

Although specific chemical resistance data are not available as yet, the materials appear to have resistance typical of ABS materials, i.e., chemical resistance somewhat characteristic of other styrene-based materials except for the significant improvement in resistance to certain reagents provided by the addition of acrylonitrile.

Applications

ABS plastics, as a family, have carved out a respectable area of application where high performance but relatively low cost is required. The new materials, according to Monsanto, should find broad use in appliances, automobiles, luggage, telephone handsets, toys and packaging. One use which may grow to substantial volume is liners for refrigerators where fluorinated hydrocarbon blowing agents are used with urethane foams in insulating. The fluorinated hydrocarbon blowing agent appears to attack the impact polystyrenes which have been used in the past. They apparently do not attack ABS materials.

Zinc Die Casting Alloy Increases Production by 10%

It also improves surfaces, reduces rejects as much as 25%

■ A new die casting alloy, Zamak-7, was recently announced by New Jersey Zinc Co., 160 Front St., New York 38. According to the producer, the alloy represents "the biggest zinc die casting breakthrough in 30 years."

Although Zamak-7—a zinc alloy containing 0.005 to 0.02% nickel and 0.005 to 0.02% magnesium—was developed approximately 30 years ago, it was not made available to industry because of the stringent purity required of the starting zinc: 99.995%. Because lower purity zinc would negate the advantages of the alloy, New Jersey Zinc says, it withheld the alloy until the entire zinc industry was in a position to furnish zinc of 99.995% purity.

Better castability

The nickel and magnesium additions increase castability of the zinc to the point where production rates are increased, on the average, by 10%. In addition, rejects are reduced 25% and surface finish is improved.

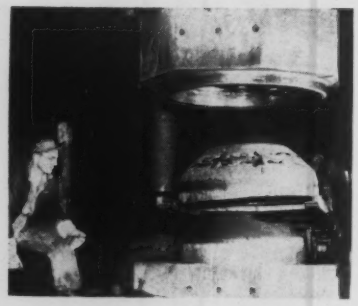
The improved castability of Zamak-7 also allows:

1. Larger, more complex castings with thinner wall sections.
2. Less critical die design. Gates and risers need not be as critically located to produce acceptable castings.
3. Lower casting temperature—which leads to increased die life.
4. Lower preplating costs because of improved surface finish.

Cost comparable to others

Cost of Zamak-7 is comparable to that of zinc-base die casting alloys. The new alloy is in commercial production and all normal shapes are available.

Largest Titanium Forgings Made In Closed Die



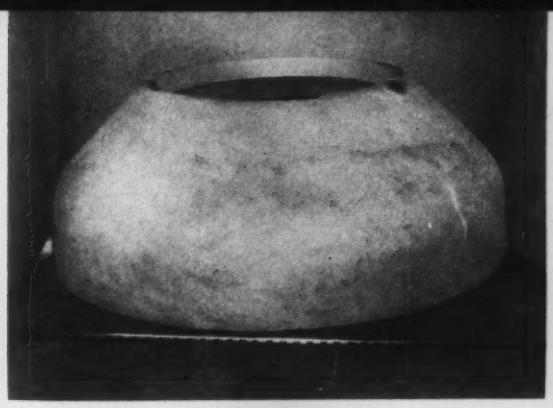
***Rear closure** weighing 441 lb is being raised from bed of 50,000-ton forging press. Forging was made using closed die technique.*

Full scale titanium rocket motor cases, up to 36 in. dia, have been forged from 13V-11Cr-3Al beta titanium alloy.

by N. G. Orrell and J. E. Coyne, *Wyman-Gordon Co.*

■ Because the 13% vanadium, 11% chromium and 3% aluminum titanium alloy can apparently achieve the 1,000,000-in. yield strength-to-density ratio sought by aircraft and missile designers, forgings made from the alloy have aroused considerable interest. A development program by the Wyman-Gordon Co. has resulted in the production of 36-in. dia rocket motor closures—the largest titanium forgings yet produced.

Recently a full size 36-in. dia rocket motor case was burst tested. The case consisted of two forged end closures joined by a fusion weld to a flow-turned cylin-



***Pancake and draw** forging technique was used to produce front closure (left) and rear closure (right) from beta titanium alloy 13V-11Cr-3Al. These were the prototypes which led to closures forged in closed dies.*

der section. All components were aged to a strength level of 180,000 psi yield strength before welding. Although the burst stress of the motor case is classified, we can report that the motor case did not shatter. The behavior of this full size motor case, as well as others subsequently tested, was similar to that of subscale test pressure vessels.

First full size components . . .

The first front and rear end closures of the 13V-11Cr-3Al alloy were produced by a pancake and draw technique using the 35,000-ton forging press with a draw ring. Typical motor case forgings are shown above.

Since these first forgings were developmental in nature, tensile specimens were taken from the first test case to determine the uniformity of mechanical properties. The forgings had been aged at 900 F for 64 hr to produce a minimum yield strength of 180,000 psi. Results of the tensile evaluation are given in Table 1. Properties of the machined forgings are uniform, as shown in the table.

. . . lead to closed die forging

Because of the encouraging results with forgings produced by the pancake and draw technique, an attempt was made to produce the closures by closed die forging. The finishing operation on the closure was performed on the 50,000-ton press as shown on p 20.

Tensile specimens were removed from the center and ring sections, and aged at 900 F for 20 and 30 hr. Results given in Table 2 indicate high uniformity of mechanical properties as well as good ductility.

. . . and a large extruded tube

The first large extrusion (25 in. long, 5.8 in. dia, 0.8 in. wall thickness) made from the 13V-11Cr-3Al alloy was extruded in a single operation in an 18,000-ton press. After aging at 900 F for 36 hr, yield strength was 185,000 psi and elongation 8%. The part is shown at the lower right.

Other parts have been successfully hammer or press forged in sizes ranging from 4⅞ in. dia up to the 36-in. dia closures just discussed. In addition, some components have been supplied in the annealed condition for subsequent cold work to increase the strength level.

Closed die advantages

Successful closed die forging of the 13V-11Cr-3Al beta titanium alloy leads to three immediate advantages:

1. Forgings can be produced with thinner walls than open die techniques permit.
2. Mechanical properties are more uniform.
3. Costs are reduced because of reduced weight and machining time.

In addition, subjecting the alloy to some form of cold work results in better control of the nucleation and growth of the aging constituent. Cold working before aging distributes the precipitate uniformly through the matrix rather than at the grain boundaries.

TABLE 1—TYPICAL MECHANICAL PROPERTIES OF MOTOR CASE COMPONENTS[a]

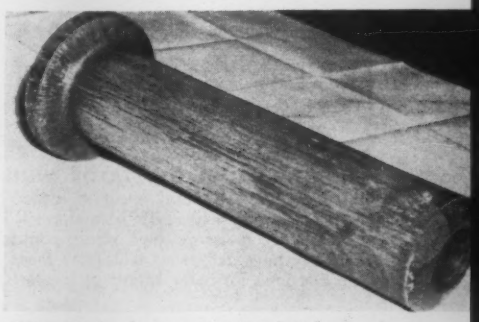
Component ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, %
Front Closure	193.4	185.8	5
	187.4	181.2	5
	194.7	188.6	4
Rear Closure	204	192.6	6
	197.5	183.2	6
	196.8	183.2	5

[a]13V-11Cr-3Al beta titanium alloy.

TABLE 2—MECHANICAL PROPERTIES OF 36-IN. DIA REAR CLOSURE FORGED IN CLOSED DIES

Location ↓	Aging[a] time, hr	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, %
Center	20	203	189	5.5
Equator	20	207	196	4
Center	30	209	191	5.5
Equator	30	208	195	3.5

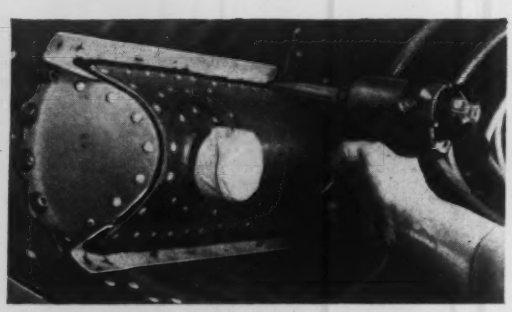
[a]Aged at 900 F, air cooled.



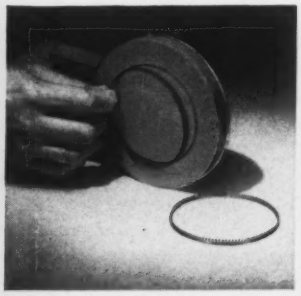
Tube *25 in. long was extruded in a single operation.*

General Electric RTV silicone rubber

New liquid rubber cures without heat, useful from — 70 F to + 600 F, ideal for sealing, electrical insulation and flexible molds.

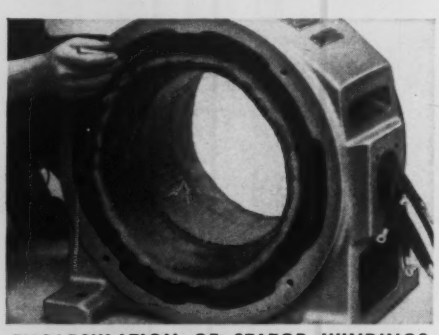


HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

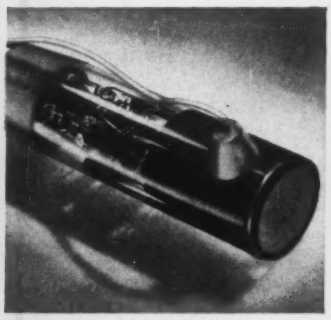


PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.

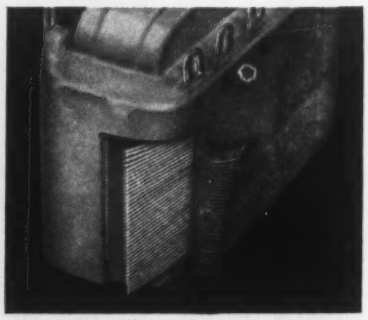
LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.



ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.



POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.



RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section B214, General Electric Company, Silicone Products Department, Waterford, New York

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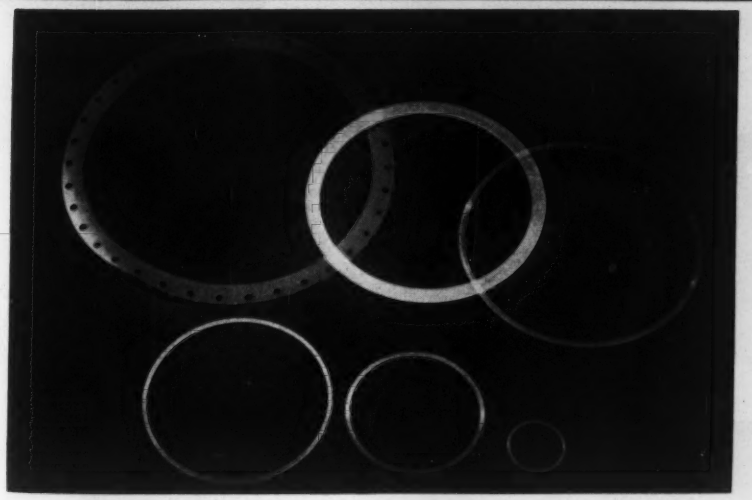
For more information, turn to Reader Service card, circle No. 434



***Chemical gasketing** is one potential use for these new fluorocarbons.*

New Lower Cost CFE Fluorocarbon Plastic

■ Two new CFE fluorocarbon plastics with performance characteristics said to be similar to those of previously available CFE fluorocarbons, e.g., Kel-F and Polyfluoron, but priced substantially lower are being marketed by the Plastics Div., Allied Chemical Corp., 40 Rector St., New York 6.

The materials, called Halon resins, are priced at $4.60 to $5.10 per lb; the lower price applying to volume sales, the higher price for small quantities (down to 1 lb). The volume price compares with $7 to $8 per lb for other CFE fluorocarbons. TFE fluorocarbon (Du Pont's Teflon) sells for $3.60-5.75 per lb. (For more information on both CFE and TFE fluorocarbons see June '57, p 129, "Selection and Design of Fluorocarbon Plastics.")

Halon resins are available as type VK, a copolymer, or type TVS, a terpolymer. Both can be processed by conventional thermoplastic forming methods, i.e., injection, compression or transfer molding, or extrusion. Both are said to have excellent processing characteristics, though type TVS is said to have somewhat the

(continued on p 145)

TYPICAL PROPERTIES OF HALON CFE RESINS

	Type →	VK	TVS
MECHANICAL PROPERTIES	ASTM		
Ten Str, 1000 psi			
At 70 F	D638	4.3	5
At 212 F	D638	1.3	3.3
At 280 F	D638	0.2	0.3
Ten Mod of Elast, 10^5 psi	D638	—	1.8
Elongation, %	D638	150	205
Flex Str, 1000 psi	D790	7.4	9.3
Flex Mod of Elast, 10^5 psi	D790	2[a]	2.2
Compr Yield Str, 1000 psi	D695	4.6	7.4
Compr Mod of Elast, 10^5 psi	D695	1	1.1
Deformation under Load (158 F, 24 hr), %			
250 Lb	D621	25	—
1000 Lb	D621	—	8.8
Impact Str (Izod), ft-lb/in. notch	D256	27[a]	4.7
Hardness (Rockwell)	D785	R75	R95
Tabor Abr Res (CS-10 wheel), 10^{-2} gm/1000 cycles	[b]	0.8	0.6
Coef of Friction on Steel			
Static		0.3	0.3
Dynamic		—	0.2
ELECTRICAL PROPERTIES			
Dielectric Str, v/mil			
Short Time	D149	490[c]	470[d]
Step by Step			
2 Mils Thick	D149	2500	1600
10 Mils Thick	D149	—	1100
13 Mils Thick	D149	1000	—
74 Mils Thick	D149	520	—
80 Mils Thick	D149	—	380
Dielectric Constant			
10^2 Cps	D150	2.8	2.6
10^7 Cps	D150	2.4	2.4
10^9 Cps	D150	2.3	—
Dissipation Factor			
10^2 Cps	D150	0.019	0.019
10^6 Cps	D150	0.017	—
10^7 Cps	D150	—	0.009
10^{10} Cps	D150	0.005	—
Vol Res, ohm	D257	$>10^{18}$	$>10^{17}$
Surface Res, ohm-cm	D257	$>10^{18}$	$>10^{16}$
Arc Resistance, sec	D495	130-140	198
PHYSICAL PROPERTIES			
Specific Gravity	D792	2.1	2.16
Ther Cond, Btu/hr/sq ft/°F/in.		1.5	1.37
Coef of Lin Ther Exp (−22 to 86F), 10^{-5} per °F	D696	0.4	2.7
Water Absorption, %	D570	0.00	0.00
Water Vapor Perm, gm/mil/100 sq in./24 hr/atm		0.18-0.05	0.015
Flammability		Nonfl	Nonfl
Effect of Outdoor Weathering (1 yr)		Nil	Under test
Refractive Index		1.426	1.425
Machinability		Exc	Exc

[a] Specimen does not fracture cleanly; no definitive failure obtained.
[b] Fed Spec L-P406-a, Method 1091.
[c] 74-mil specimen.
[d] 80-mil specimen.

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IMPACT!

This is a "warhead". It's the front end of a carrier which darts through a pneumatic tube system at speeds up to 20 mph, and is subject to frequent shocks and impact. There's a story behind the choice of LEXAN® polycarbonate resin for this new design . . .

Formerly, destinations were set by contacts along the entire body of the carrier. Engineers of Airmatic Systems Corporation, Saddle Brook, New Jersey, reasoned that if all the control elements could be fitted into a small impact- and wear-resistant head, the rest of the carrier could be designed for easy maintenance and quick replacement. Many plastics had the required dielectric strength, but none could measure up to LEXAN resin's combination of good electrical properties, excellent dimensional stability and extremely high impact strength. LEXAN resin actually withstands over 12 foot-pounds per inch of notch — an impact strength attained by no other plastic!

The new warhead is injection-molded of black LEXAN resin by Berkeley Engineering & Manufacturing Co., Berkeley Heights, N. J. Now when wear and tear take their toll, the transparent carrier body is easily replaced, since it has no control elements. Also, body length can be varied to suit customer needs, and carrier weight is reduced. Printed circuits and compactly arranged brushes and control plates are used. The new design is more attractive, more practical, less costly. And—LEXAN resin warheads have proved in field tests to last longer than the old control units.

G.E. LEXAN polycarbonate resin has raised the quality of many designs to new levels. It has been reduced in price approximately 40% over the past year! Can this tough, new thermoplastic help you? Send for design literature.

LEXAN®
Polycarbonate Resin

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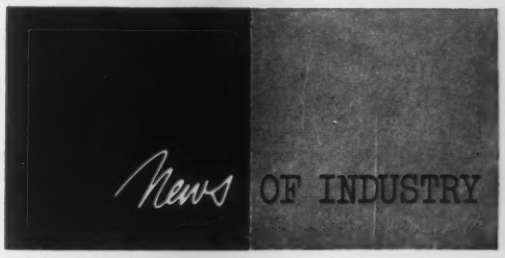
Chemical Materials Dept., Section M-21, Pittsfield, Mass.

For more information, turn to Reader Service card, circle No. 376



Materials Science Center to be Set Up at Illinois

■ The government is stepping up its program to overcome critical materials barriers and the shortage of materials specialists.

A recent report by the Joint Congressional Committee on Defense Production states that the Atomic Energy Commission and the National Aeronautics and Space Administration are planning to spend up to $20 million in the next three years to establish and support a materials science center at the University of Illinois. The new laboratory, which will be operated along interdisciplinary lines, will be devoted almost entirely to basic studies in materials.

Graduate education also a goal

Chemists, metallurgists, ceramists, and physicists will work side by side in the projected laboratory on common problems that require solutions to speed our advance in the fields of space exploration and atomic energy. Another important result of the program will be to increase the output of Ph.D's in materials sciences by 24 to 36 a year.

Financial support for the new materials center will be divided as follows: The AEC will spend an initial $5.6 million to establish the laboratory and then provide $2.5 to $3.0 million annually. The NASA will support the program "to the extent of $4 million in fiscal year 1960, $5 million in fiscal 1961, and still more in fiscal 1962."

The materials center at Illinois will bring the total of such establishments to four. During the past year the Defense Dept. awarded contracts to the Universities of Pennsylvania, Cornell and Northwestern to establish similar materials research centers.

Projects clarify federal policy

These four projects are among the first concrete demonstrations of the federal government's recently declared policy to support basic research within the framework of our universities. The overall pattern for the nation's basic research effort that is now emerging was spelled out in a report issued last month by the President's Science Advisory Committee. The 33-page document is called "Scientific Progress, the Universities and the Federal Government."

The government's philosophy of basic research as it applies to the materials field was discussed recently in M/DE (Dec '60, p 192). As stated there: "Our course in basic materials research on a national level has been set. Success or failure is now largely in the laps of our universities."

Three Metals Meetings Coming

Three technical societies in the metals field will hold meetings in the next three months:

The Metallurgical Society of AIME (Feb 26-Mar 2, St. Louis)—A symposium on metallurgy in the Air Force on Feb 27 will be a highlight of the society's annual meeting.

Prior to the technical meetings, the Education Committee will hold a panel discussion on university-sponsored research and its function.

12th Western Metal Congress and Exposition (Mar 20-24, Los Angeles)—"Idea Center for Industry West" is the theme of the Congress and Exposition sponsored by six engineering organizations.

Over 100 papers will be presented. Topics will include alloying, selection, testing, joining and cutting. More than 200 firms will have displays at the Exposition.

Participating societies are: American Society for Metals, Metallurgical Society of AIME, American Society for Testing Materials, Society for Nondestructive Testing, American Welding Society, and Society of Aerospace Materials and Process Engineers.

The Society of Aerospace Materials and Process Engineers became a national organization last October (see M/DE, Jan '61, p 21). SAMPE will sponsor two half-day sessions at the Congress. Topics will include materials systems programming, pyrolytic graphite and prestressed ceramics.

American Welding Society (Apr 17-21, New York City)—New developments in welding, brazing, fabrication and testing of a wide variety of metals and structures

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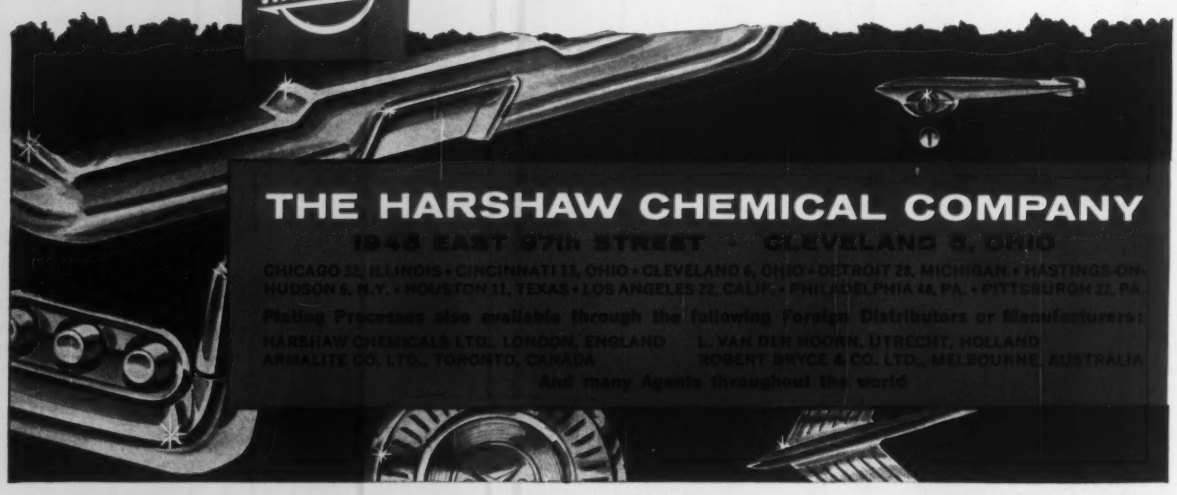

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will be discussed in the 22 technical sessions of AWS's 42nd annual convention and exposition.

The society will also be host to the International Institute of Welding during this meeting.

New OTS Translations Program

Six new monthly publications of Soviet and Communist Chinese abstracts will be available from the Office of Technical Services starting next month. Together they will furnish about 1500 translated abstracts each month from more than 200 scientific and technical journals.

The new OTS service divides all science and technology into six broad areas. Physics, chemistry and metallurgy are covered in three separate publications along with related topics.

The new program makes it possible in most cases for a scientist to keep up with his field by subscribing to only one Soviet-Chinese abstract publication.

According to James Wheat, director of public information for the Commerce Dept. agency, each of the new publications will run from 150 to 450 abstracts per month. Average abstract length is estimated to be at least 500 words. Subscriptions range from $6 to $18 for six months.

Old program dropped

Previously, OTS had offered 100 publications that boiled down every article appearing in 100 Soviet and Soviet-bloc journals. This program was dropped last summer when lack of public demand caused OTS to develop the new program.

Dropping the old program led to publication of an Associated Press report in December that OTS had curtailed its translation activities.

"This report is a misinterpretation," Wheat says. "The new program is broader than the old, and we think it will be more useful as well."

NATO Group Urges Europeans to Centralize Materials Research

Materials science and engineering is suggested as one of the principal study areas for a European institute of science and technology in a recent report by the North Atlantic Treaty Organization.

The report, called "Increasing the Effectiveness of Western Science," is the result of an independent study by NATO's Science Committee.

The report, issued here by the National Science Foundation, concludes that it would be advantageous for European nations to centralize their research in an international institution. Among other aims, it is felt that such a concentration would most effectively coordinate the methods of physics, chemistry and engineering in the field of materials.

Industrial R&D Up 15% in 1959

Industry spent $9.4 billion for research and development in 1959, an increase of 15% over the 1958 level, the National Science Foundation reported recently.

Estimates received by NSF indicate an 8% increase in 1960 with expenditures expected to reach $10 billion.

The aircraft, electrical equipment and communications, chemical, machinery and transportation industries had the largest 1959 research budgets, NSF said.

News of Societies

Aerospace Industries Assn. has elected the following: chairman of the board of governors—J. V. Naish, Convair; vice-chairman—H. M. Horner, United Aircraft Corp.; re-elected president—O. R. Cook; chairman, service publications committee—R. Nelsen, General Electric Co.; vice-chairman—R. H. Lambka, Bendix Corp.

American Institute of Mining, Metallurgical and Petroleum Engineers has awarded the James Douglas Gold Medal to Dr. Frank H. Spedding, director of the Institute for Atomic Research, for his contributions to extractive metallurgy and atomic energy.

American Iron and Steel Institute has elected W. G. Kirkland and R. E. Paret as assistant vice-presidents.

American Iron and Steel Institute stitute has announced the establishment of a Western Pennsylvania Section, and has elected the following section officers: chairman — M. E. Jetty, Brockway Pressed Metals; vice-chairman—G. J. Hoehn, International Powder Metallurgy Co.; treasurer—C. J. Bloom, Crane Co.; secretary—J. M. Eberhart, Brockway Pressed Metals.

American Society for Testing Materials has elected A. A. Marra, professor of wood technology at the University of Michigan, as chairman of the Committee on Adhesives.

National Electronics Conference has announced the following 1961 officers: president—J. J. Gershon, De Vry Technical Institute; vice-president—J. H. Kogen, GPE Controls, Inc.; secretary—Dr. T. F. Jones, Jr., Purdue University; treasurer—R. J. Parent, University of Wisconsin; re-elected as chairman of the board—W. O. Swinyard, Hazeltine Research Inc.

National Insulation Mfg. Assn. has elected I. Keith as treasurer and E. L. Kells to the technical and research committee. Both men are executives of Forty-Eight Insulations, Inc.

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Coming Meetings

MATERIALS FOR NUCLEAR APPLICATIONS SYMPOSIUM, American Society for Metals, Albuquerque, N.M. Feb 16-17.

AMERICAN INSTITUTE OF MINING, METALLURGICAL & PETROLEUM ENGINEERS, annual meeting. St. Louis. Feb 19-23.

TECHNICAL ASSOCIATION OF THE PULP & PAPER INDUSTRY, 46th annual meeting. New York City. Feb 20-23.

AMERICAN INSTITUTE OF MECHANICAL ENGINEERS, annual meeting. St. Louis. Feb 26-Mar 2.

GAS TURBINE POWER CONFERENCE & EXHIBIT, American Society of Mechanical Engineers. Washington, D.C. Mar 5-9.

STEEL FOUNDERS' SOCIETY OF AMERICA, 59th annual meeting. Chicago, Mar 11-14.

AVIATION CONFERENCE, American Society of Mechanical Engineers. Los Angeles. Mar 12-16.

TEXTILE ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Clemson, S. C. Mar 16-17.

AMERICAN SOCIETY FOR METALS, 12th Western Metal Congress & Exposition. Los Angeles. Mar 20-24.

INSTITUTE OF PRINTED CIRCUITS, 3rd annual meeting. New York City. Mar 21-22.

AMERICAN CHEMICAL SOCIETY, 139th national meeting. St. Louis. Mar 21-30.

FILAMENT WINDING CONFERENCE, Society of Aerospace Material & Process Engineers. Pasadena. Mar 28-30.

MATERIALS FOR ELECTRON TUBES AND SEMICONDUCTOR DEVICES, American Society for Testing Materials. Philadelphia. Apr 5-7.

MANAGEMENT ENGINEERING CONFERENCE, American Society of Mechanical Engineers. New York City. Apr 6-7.

AGGLOMERATION SYMPOSIUM, American Institute of Mining, Metallurgical and Petroleum Engineers. Philadelphia. Apr 12-14.

AMERICAN WELDING SOCIETY, 42nd annual convention and exposition. New York City. Apr 17-21.

DESIGN ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Detroit. May 22-25.

SOCIETY OF THE PLASTICS INDUSTRY, 9th National Plastics Exposition and Conference. New York City. June 5-9.

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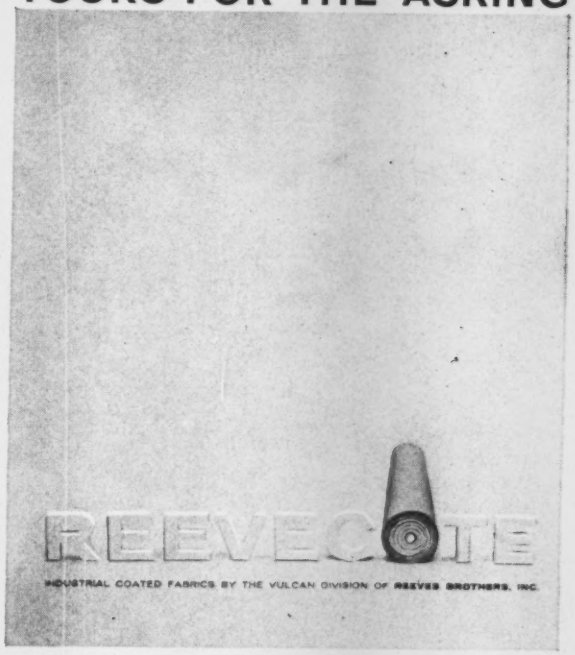

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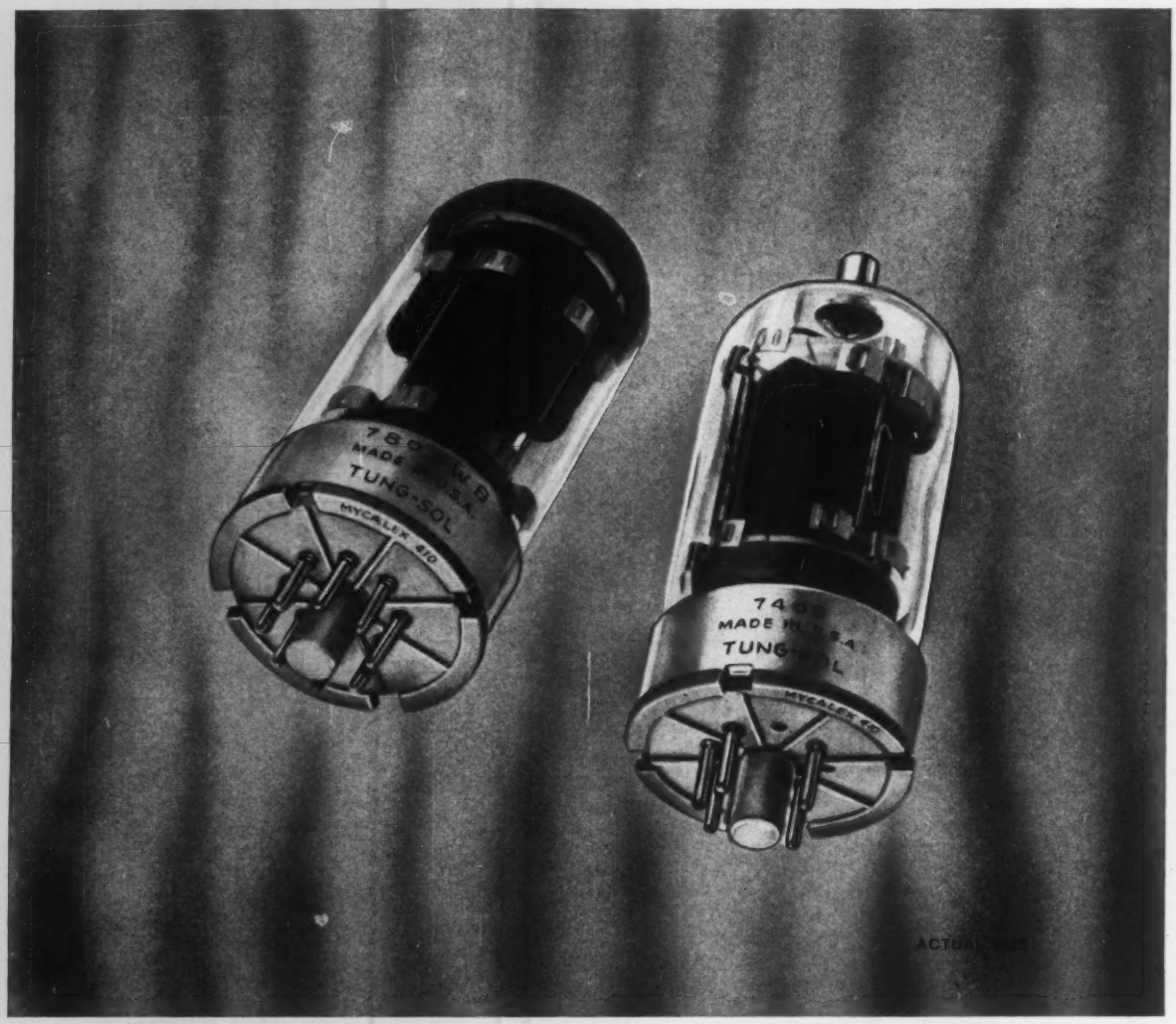

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Exceptions to our automobile report

To the Editor:

We were pleased to note your recognition of the polycarbonates in November's special report ("Automobiles: What Materials Are Next," M/DE, Nov '60, p 143). However, certain observations therein contradict the facts established in more than three years of field and laboratory experience with Lexan polycarbonate resins.

The most serious is the statement that shrinkage is a problem. One of the outstanding characteristics of polycarbonate parts is their excellent dimensional stability in a wide variety of environments. In addition, the molder finds polycarbonate shrinkage predictable and very low—lower than in the other engineering plastics with which it might compete.

Although your editor was told polycarbonates have "an uncertain surface finish," experience shows polycarbonates reproduce mold finishes very faithfully. Gloss depends on mold characteristics, not the resin. In addition, polycarbonate parts may be lacquered, painted, metallized, or flame sprayed. Good adhesion is obtained by all these techniques.

As to low temperature performance, tests and field evaluations have shown that polycarbonate essentially maintains its physical properties to and below —60 F. Its brittleness temperature is below —215 F.

Polycarbonate costs can be a stumbling block in some applications, as noted. However, the latest price decrease, the second in less than six months, drops the cost to 5.6¢ per cu in., or about 14% less than the quoted figure.

R. J. THOMPSON,
Manager, Polycarbonate Market Development
Chemical and Metallurgical Div.
General Electric Co.
Pittsfield, Mass.

Mr. Thompson's comments are a welcome supplement to the special report on materials problems of the automotive industry. As noted in the original article, our information was primarily obtained through interviews with actual users in the auto industry. In the case of the polycarbonates, it is apparent that the users we talked to probably did not have all the facts. Thus, we are glad to set the record straight.

To the Editor:

I was disappointed to see that no mention was made of reinforced polyester premix in the metals vs plastics section of the special report on automobiles.

Premix moldings average almost 3 lb per unit in the 1961 models, with a high of about 10 lb in

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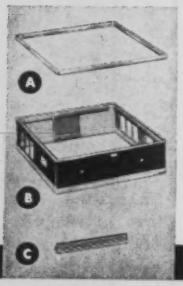

This new Webcor tape recorder weighs 19 lbs., has a case with three vital parts of extruded aluminum by General Extrusions Inc. G.E.I. engineers easily met the manufacturer's design specifications, then the parts were formed, drilled, punched, mitered, anodized and spray painted in G.E.I.'s modern plant in time to meet exacting delivery schedules. Why not let G.E.I. help get your new product off the drawing board and into production?

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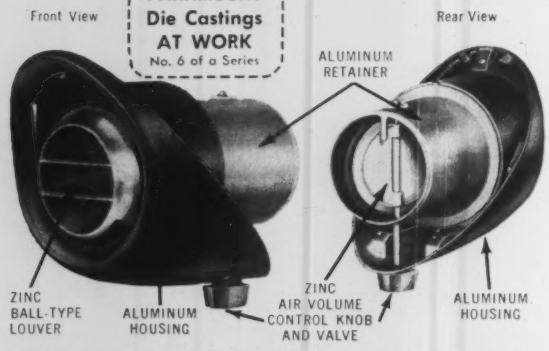

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the Chrysler lines and slightly over 5 lb on Ford models. While its main use now is in heaters and air conditioners, many other parts can be economically and satisfactorily molded in premix. At a cost of under 0.8¢ per cu in., it cannot be touched by any of the thermoplastics now being used.

KEITH D. GEHR
Research Div.
Weyerhaeuser Co.
Longview, Wash.

Those interested in premix may want to refer to a previous M/DE article, "Premix Plastics Moldings for Low Cost Parts," Sept '55, p 104.

Using probability paper

To the Editor:

I would appreciate a half dozen reprints of the article "How to Use Probability Paper to Solve Materials Problems" (M/DE, Nov '60, p 138). I think the inclusion of the information on the use of log paper is a definite improvement over your 1956 publication.

The question which we have never been able to resolve in using probability paper is how to handle the fact that it is not possible to plot 100%. I notice that you handle this by splitting the difference; i.e., for ten observations you start at 5% and end at 95%. Some of my colleagues prefer to assume (say in the case of 15 observations) that they have 16 points and plot the first 15. The first point is at 6.25%, the second at 12.5% and the fifteenth at 93.75%.

I wonder whether you know of any literature references or other reasons for preferring one system to another.

MARTIN S. FRANT
Research Associate
AMP, Inc.
Harrisburg, Pa.

The 100% point cannot be plotted because, on this type of scale, it is located at infinity. Actually, for practical engineering purposes, this final point has little significance and can be ignored. Although we cannot cite any references, we suggest you follow the table of cumulative percentages and number of observations. To determine the cumulative percentage intervals, divide 100 by the number of observations. The first and last points are plotted at one-half the interval. All points after the first one are plotted at the full interval. Thus for 25 observations, the first and last points are 2% and 98%; all points in between are at 4% intervals, i.e., 6%, 10%, etc.

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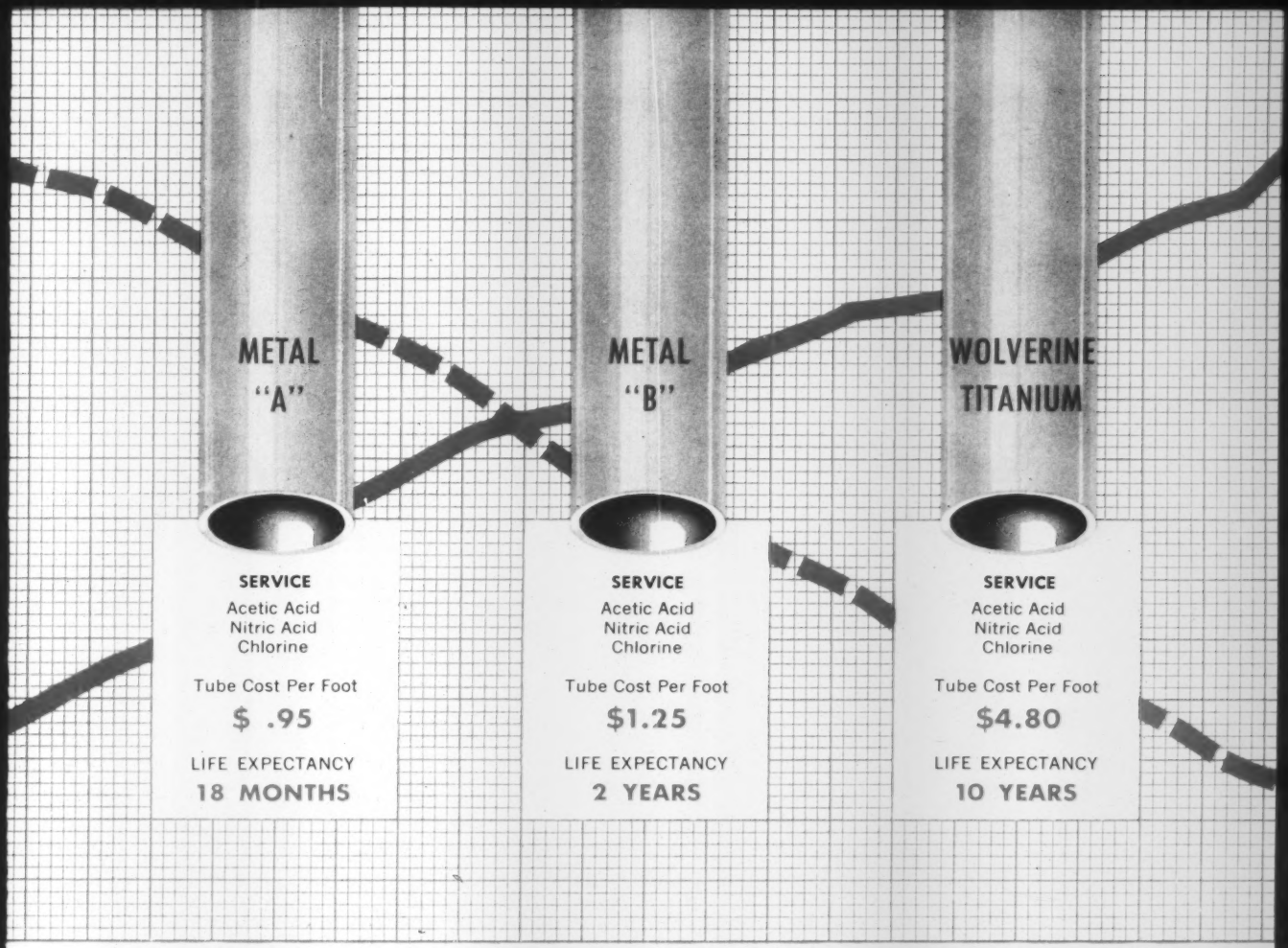

Consider the long range payout of Titanium vs standard metals and alloys

Wolverine Tube is certain that you know all about equipment payout—and how it can be affected by costly maintenance and downtime, particularly in corrosive services.

But perhaps you haven't considered how important it is to look beyond first costs—to get the big picture of what Wolverine titanium heat exchanger tubing can do for your company's long range requirements.

In addition to the services illustrated in the charts above, consider the increasing use of sea water for cooling purposes. Most ferrous and nonferrous alloys in this service have a tendency toward stress corrosion cracking and pitting. On the other hand, titanium is completely immune to these faults when handling salt water. Thus, as in the services charted above, titanium heat exchanger tube, though having a greater first cost, is more economical in the long run because it gives greatly increased and uninterrupted service life.

It's a big subject and one that requires more space than we have available here. Why not talk it over with your Wolverine sales representative? He can point out in detail the many ways in which titanium heat exchanger tube can save you time and money.

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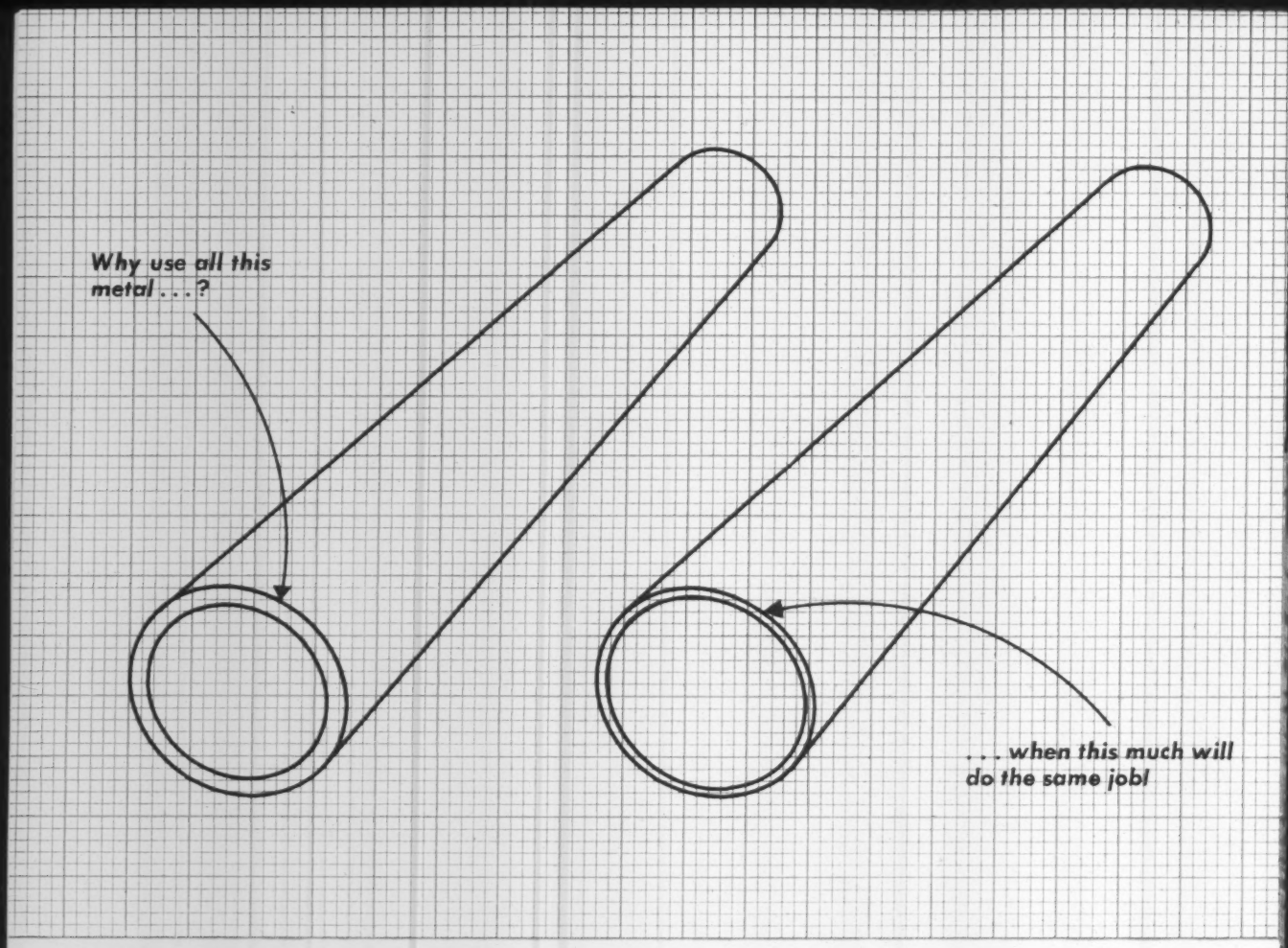

Wolverine Titanium Heat Exchanger Tube helps eliminate waste metal

When analyzing the effectiveness of titanium heat exchanger tubing, in comparison with standard metals and alloys, it must be remembered that because of titanium's great resistance to corrosion, a lighter walled tube can be used in many applications.

For example, Wolverine titanium heat exchanger tube with .049″ wall thickness and less can successfully handle products such as acetic acid, nitric acid and chlorine—among others. When compared to the much heavier walled tubing in certain other metals normally used in such services, it is apparent that substantial savings can be made in both unit weight and structural support.

This important factor also helps reduce the end cost of titanium heat exchanger tube and makes this metal even more attractive when compared to other metals having lower initial cost, but requiring heavier wall thickness because of their accelerated corrosion rate.

For complete information about Wolverine titanium heat exchanger tube, just talk to your Wolverine sales representative. He can give you the entire story about Wolverine's work in titanium and other special metals.

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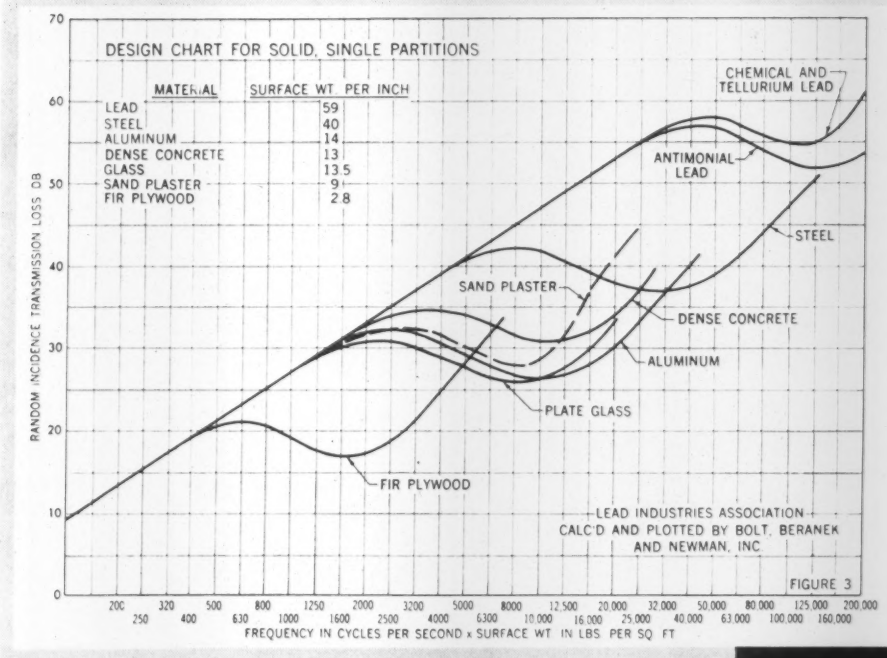
As the table and chart show, lead's unique combination of limpness and density enables it to block sound transmission more effectively than common construction materials. As a result, wherever weight and space are important, it makes engineering sense to use lead for noise attenuation.

The data shown are excerpts from a new twelve-page research report prepared by the acoustical consultant firm of Bolt, Beranek and Newman. It contains extensive engineering information on noise control.

A copy of this report is available by request on your company letterhead.

Type of Partition	Weight of Partition lb/sq ft	Weight of Partition equiv. lead* lb/sq ft	Weight Ratio	Thickness inches	Thickness equiv. lead inches
Plywood	2.25	0.47	4.9	3/4	1/128
Sheet Steel [1]	3.0	1.8	1.75	1/16	1/32
Solid Plaster	18	3.75	4.8	2	1/16
Cinderblock	22	5.5	4.0	6	3/32
Plaster on studs	12	7.5	1.6	4-6	1/8
Plaster on double studs	16	11.0	1.4	5-8	3/16
Brick	104	15.0	7.0	8	1/4



1) as employed in a movable partition, for example.

*Lead required to provide an equal degree of sound transmission loss.

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NS SPECIAL WIRE WITHSTANDS 1000°F

Landing hot jets like the McDonnell Phantom II at high speeds, means brakes and brake components must be able to withstand extreme temperatures without failure.

A leading manufacturer of brakes for jet aircraft came to National-Standard for help in finding a spring wire that would have high stress-temperature stability up to 1000°F. National-Standard engineers recommended an austenitic superalloy material, NS-A286, recently developed for spring wire applications by National-Standard. Tests showed that NS-A286 met requirements better than any other available alloy, yet cost only half as much as the next best alloy.

SUPERALLOY PASSES TEST—When brakes on the Phantom II are released, the NS-A286 return springs under the brake discs must separate the stationary stator discs from the moving rotor discs. The brake discs build up heat to 1400°F, which is quickly absorbed by the return springs, raising spring temperatures to as much as 1000°F. NS-A286 is a precipitation hardening alloy exhibiting as little as half the relaxation loss at 1000°F as comparable alloys show at 850°F. NS-A286 springs must retain their strength at this heat to separate the brake discs and guard against brake drag during landings.

To test NS-A286, engineers simulated stress-temperature characteristics of three landing conditions.

TO BRAKE JETS

Heat builds up in the brakes in 30 seconds and remains for as long as 20 minutes. The springs must work in the heat against a high back pressure maintained in the aircraft hydraulic system. Springs must be operational for at least 45 normal landings, 5 high-speed, gross weight landings, and one aborted take-off stop, corresponding to stopping the plane just before it becomes airborne. Under all test conditions, NS-A286 met every rigid requirement.

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NS SPECIAL WIRE WITHSTANDS 1000°F

Landing hot jets like the McDonnell Phantom II at high speeds, means brakes and brake components must be able to withstand extreme temperatures without failure.

A leading manufacturer of brakes for jet aircraft came to National-Standard for help in finding a spring wire that would have high stress-temperature stability up to 1000°F. National-Standard engineers recommended an austenitic superalloy material, NS-A286, recently developed for spring wire applications by National-Standard. Tests showed that NS-A286 met requirements better than any other available alloy, yet cost only half as much as the next best alloy.

SUPERALLOY PASSES TEST—When brakes on the Phantom II are released, the NS-A286 return springs under the brake discs must separate the stationary stator discs from the moving rotor discs. The brake discs build up heat to 1400°F, which is quickly absorbed by the return springs, raising spring temperatures to as much as 1000°F. NS-A286 is a precipitation hardening alloy exhibiting as little as half the relaxation loss at 1000°F as comparable alloys show at 850°F. NS-A286 springs must retain their strength at this heat to separate the brake discs and guard against brake drag during landings.

To test NS-A286, engineers simulated stress-temperature characteristics of three landing conditions.

TO BRAKE JETS

Heat builds up in the brakes in 30 seconds and remains for as long as 20 minutes. The springs must work in the heat against a high back pressure maintained in the aircraft hydraulic system. Springs must be operational for at least 45 normal landings, 5 high-speed, gross weight landings, and one aborted take-off stop, corresponding to stopping the plane just before it becomes airborne. Under all test conditions, NS-A286 met every rigid requirement.

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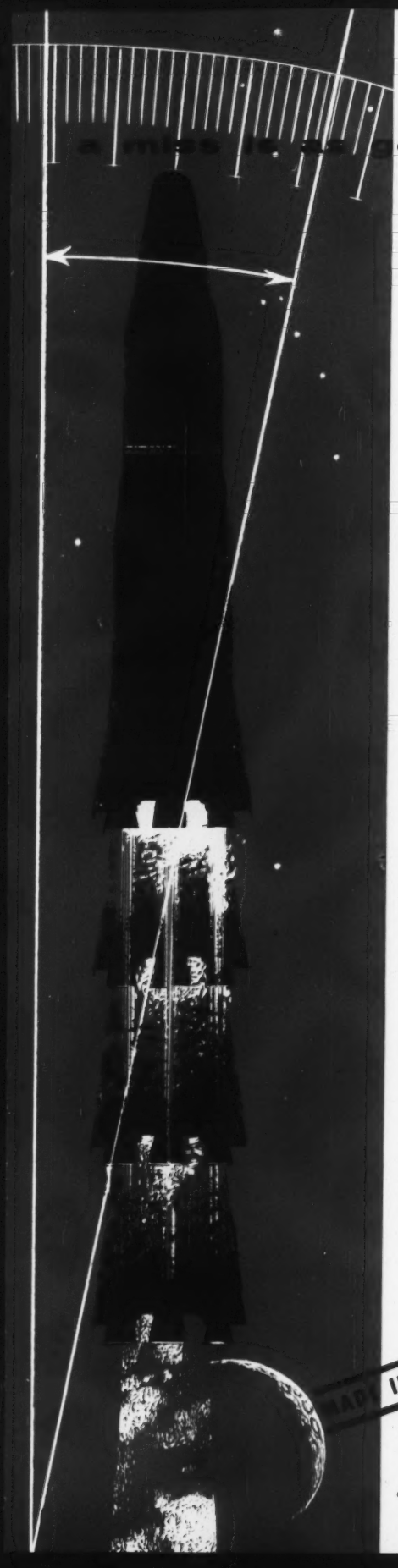

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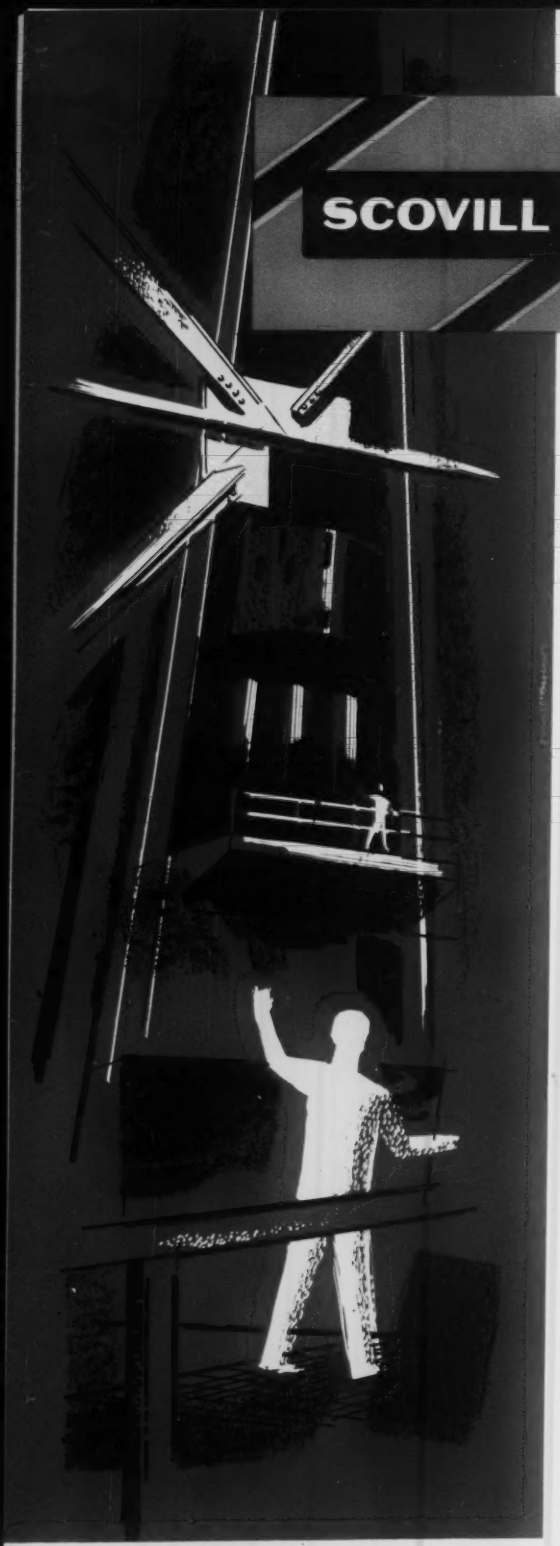

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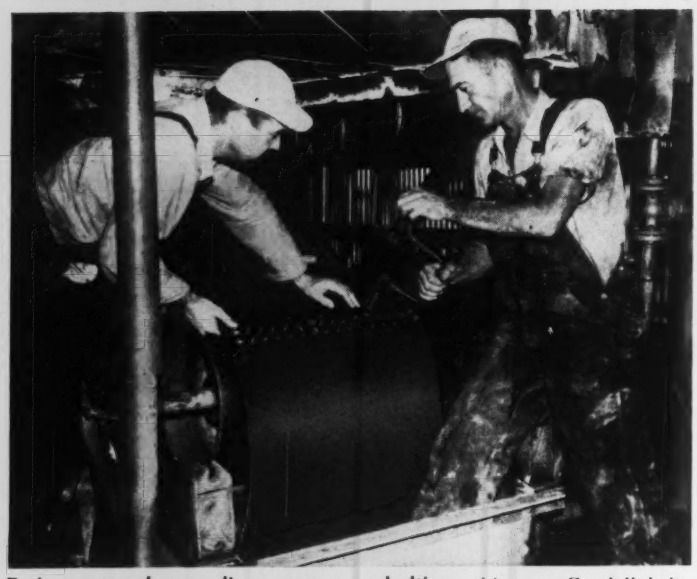
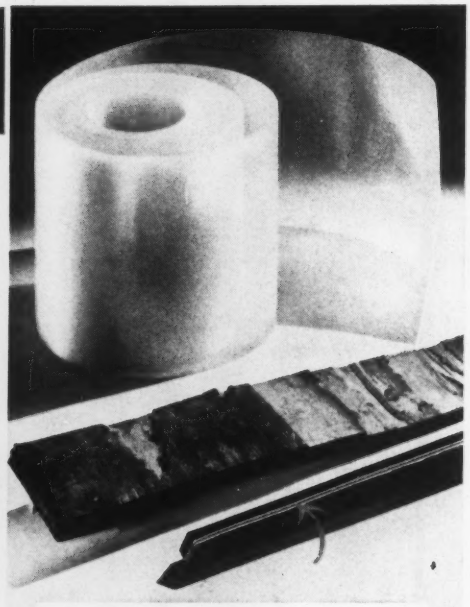


Twice as tough as ordinary conveyor belting, this new Goodall belt lasts 50% to 100% longer—thanks to its core of oriented nylon sheeting made from a special Spencer resin (see right).



This is the secret—using oriented nylon sheeting (top) as the core of belting (arrow), can double its life. This worn nylon-core belting (center) outlasted its predecessor by more than 100%! In one New York tunnel project where the belt was used the contractor estimated that the number of belts could have been cut 50% if the new Goodall belt had been available for the entire operation. Read more about this important development below:

Oriented Nylon Core Doubles Life Of Giant Conveyor Belts

Another Example of How Spencer Nylon Solves Material and Design Problems

Now Spencer Nylon is helping to dig tunnels and mines. This has all come about because Goodall Rubber Company, Trenton, N. J., set out to develop a new super-strength conveyor belting—the kind needed for the rugged work of hauling rock and muck out of tunneling excavations.

Where do you turn when you want help in pioneering a new application for nylon? Like many other innovators, Goodall found the services of Spencer's technical representatives are invaluable. Spencer's nylon experts came up with just the precise resin required for the job.

Using a special grade of nylon, supplied by Spencer, Moldings & Extrusions, Inc., of Wauregan, Conn., perfected an exclusive process for orienting wide sheets of nylon. This extra toughening step increases the tensile strength and greatly reduces its tendency to elongate. Because the huge belts become virtually stretch-proof, much down-time formerly required for shortening and retightening is eliminated.

Acclaimed the most durable belting ever produced, this Goodall achievement is expected to find wide acceptance in many other materials handling applications—particularly where "wicking" of chemicals has been destructive to the conventional core materials used in ordinary belts.

Using Spencer Nylon by the mile, Moldings & Extrusions, Inc., is extruding and orienting its ultra-durable sheeting on a full-scale production schedule. The superior processing qualities of Spencer Nylon offer important advantages. Its heavy body facilitates precision extrusion. Costly drying time is eliminated because Spencer Nylon contains far less water than other nylons.

Discover for yourself how Spencer Nylon can fit your job requirements as no other nylon can. For information and technical assistance without obligation, contact Spencer Chemical Company at the address below:

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Porcelain Enamel. Porcelain Enamel Institute, 1145 19th St., N. W., Washington 6, D. C. File folder covers general information about porcelain enamel, gives characteristics, properties and corrosion resistance of porcelain enamel. Write on company letterhead directly to Porcelain Enamel Institute.

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Methods & Equipment

• *Testing*

Hardness Tester. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 2 pp, illus., No. TT-58. Dimensions, features, operational data and prices of a Rockwell hardness tester. **150**

Alloy Identification. Budd Co., Instruments Div., 4 pp, illus. General information on an eddy current testing device which identifies alloys and heat treat conditions of both ferrous and nonferrous metals; checks degree of carborization; measures thickness of platings and insulating coatings; and detects parts that fall below specifications for heat treatment, hardness, strength, and composition or purity. **151**

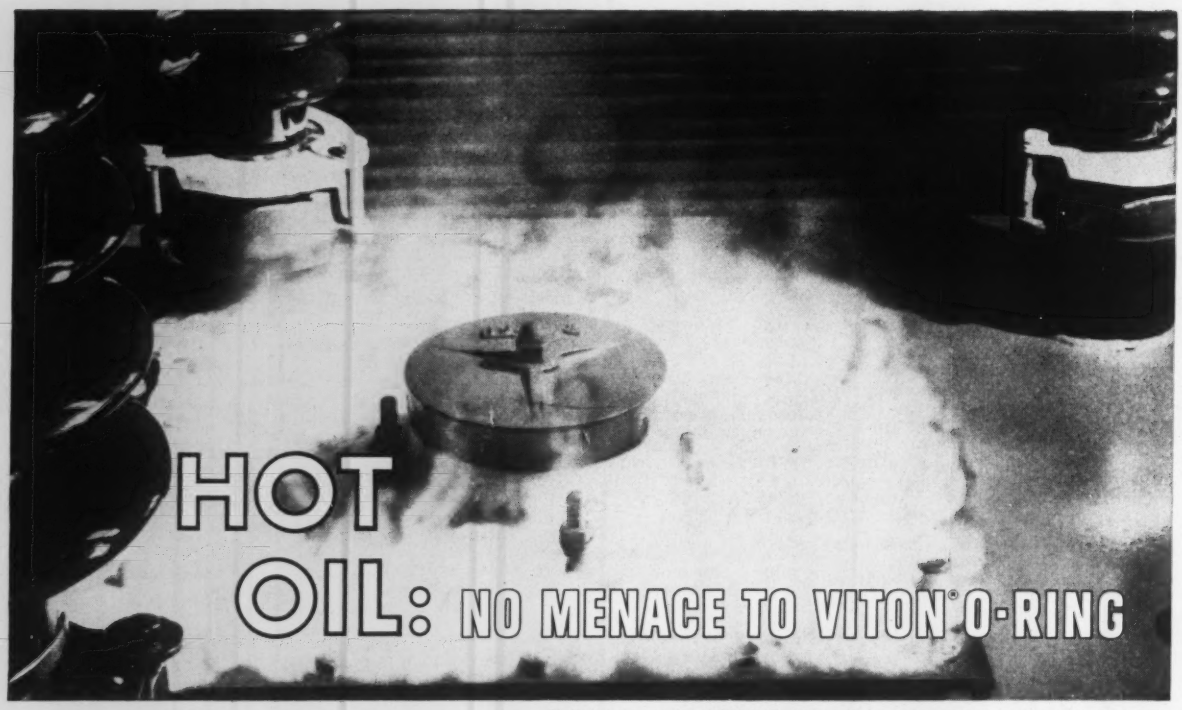
Metalworking Machine. Cincinnati Milling Machine Co., Meta-Dynamics Div., 8 pp, illus. Operational data, advantages and characteristics of a metal working machine used for "chipless" machining. **152**

Processing X-Ray Films. Eastman Kodak Co., X-Ray Div., 6 pp, illus. Describes an entirely new system of faster, better processing for industrial x-ray film. **153**

Electric Furnaces, Kilns. Pereny Equipment Co., 8 pp, illus., No. 570. Information on electric heat treating, melting and sintering furnaces, and electric ceramic kilns. **154**

Compacting Presses. F. J. Stokes Corp., 2 pp, illus., No. 123. Series of photographs identify this company's line of single punch presses, rotary presses and various punches and dies used for compacting. **155**

Testing Materials. United States Testing Co., Inc. Two pamphlets, Nos. 1 and 2 of a series, describe the latest in testing, research, development, design and instruments for materials, components, and products. **156**



HOT OIL: NO MENACE TO VITON® O-RING

Relief valve, using VITON O-ring, vents excess pressure from transformer.

The ideal pressure-sensitive relief valve for sealed, oil-filled transformers should be "selective." It should withstand normal pressure changes, yet respond quickly to emergencies.

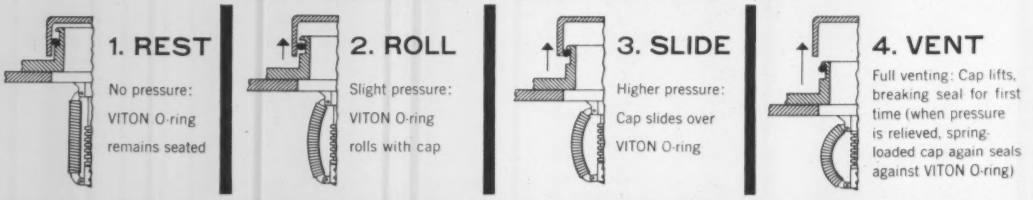
General Electric's Medium Transformer Department at Rome, Georgia, designed a mechanical relief valve that would not only solve this problem of selectivity, but would actually reset itself after discharge. The valve's success depended on an O-ring able to maintain a tight seal in spite of repeated exposure to hot insulating oil. With an O-ring made from VITON synthetic rubber, this novel spring-loaded relief valve has proved itself both faster and more reliable than previous devices*.

OTHER APPLICATIONS OF VITON

VITON'S outstanding resistance to heat, oil, fuels, solvents and chemicals has improved the performance of a wide range of industrial equipment. O-rings, packings and seals have been molded from VITON . . . tanks have been lined, fabrics have been coated and wire has been jacketed . . . all with VITON. If *you* have a problem involving high temperatures and corrosive fluids, VITON will serve where other elastomers fail. See your rubber goods supplier for information, or write for our booklet of specific data, with current and suggested applications. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MDE-2, Wilmington 98, Del.

**Case history from the* ELASTOMERS NOTEBOOK—*subscription free on request.*

HOW RELIEF VALVE USES VITON O-RING


1. REST
No pressure: VITON O-ring remains seated
2. ROLL
Slight pressure: VITON O-ring rolls with cap
3. SLIDE
Higher pressure: Cap slides over VITON O-ring
4. VENT
Full venting: Cap lifts, breaking seal for first time (when pressure is relieved, spring-loaded cap again seals against VITON O-ring)

DU PONT
REG. U. S. PAT. OFF.

VITON®
SYNTHETIC RUBBER

Better Things for Better Living . . . *through Chemistry*

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TECHNICAL LITERATURE

Books

The Structure of Glass: Vol 2. *Consultants Bureau Enterprises, Inc., New York. 1960. Cloth, 8½ by 11 in., 492 pp. Price $25*

Published simultaneously in New York and Leningrad, this book is the second in a series of books on glass structure translated from the Russian and based on the Proceedings of the All-Union Conference on the Glassy State, held in Leningrad. The first volume was published in 1958.

The book presents a complete account of research work conducted on the glassy state since the previous conference held in 1953. Some of the subjects covered: principal methods and results of glass structure studies; relationship between the structure and properties of glasses; nature of the chemical bond and the structure of glasses; crystal chemistry of glass; silicate melts—mechanism of glass formation; optical properties and structure of glasses; electrical properties of glasses; physicochemical properties of glasses; coloration of glasses and action of radiation; mechanical and technical properties of glasses; chemical properties of glasses; semiconductor glasses; and sodium borosilicate glasses.

1961 SAE handbook. *Society of Automotive Engineers, Inc., New York. 1961. Cloth, 8¾ by 11¼ in., 900 pp. Price $20*

The latest edition of this well-known handbook contains a total of 396 reports, of which 24 are new, 78 technically revised, and 24 editorially changed. Among the new reports are discussions of the following four nondestructive test methods: ultrasonic inspection, industrial inspection radiography, eddy current testing, and liquid penetrant test methods. Other new reports include a method for determining breakage allowance for steel sheets, and lubricant types.

Theory of Thermal Stresses. *B A. Boley and J. H. Weiner. John Wiley & Sons, Inc., New York. 1960. Cloth, 6 by 9 in., 586 pp. Price $15.50*

Discusses and explains all of the presently available techniques for determining stresses produced in a solid object subjected to specified heating conditions.

The book is divided into four parts: 1) fundamentals of thermoelasticity: 2) an account of heat transfer theory, including methods of solving heat conduction boundary-value problems: 3) practical aspects of thermal stress analysis (from the strength-of-materials point of view), including methods of analyzing beams, plates, and various built-up structures: and 4) the manner in which temperature effects can be included in inelasticity theory.

Polypropylene. *Theodore O. J. Kresser, Reinhold Publishing Corp., New York. 1960. Cloth, 5 by 7½ in., 268 pp. Price $6.50*

This volume, the 19th in the "Plastics Applications Series," covers properties, chemistry, production and processing of polypropylene. Several important chapters are devoted to applications of polypropylene in the packaging, appliance, automotive and housewares industries. A final chapter discusses future developments.

Progress in Powder Metallurgy: Vol 16. *Metal Powder Industries Federation, New York. 1960. Cloth, 8 by 9¾ in., 215 pp. Price $10*

Includes all technical papers presented at the Metal Powder Industries Federation's 16th annual technical meeting held last April. Subjects include: ultrasonic inspection; machinability of sintered iron; nondestructive testing of cemented carbides; process controls; checking density variations; effect of particle size distribution on the sintering of molybdenum; heat treatable steel-bonded carbides; sintered nickel steels; dispersion strengthening; stainless steel powder metallurgy; low temperature impact strength of powder metallurgy parts; aircraft superalloys by powder metallurgy; outlook for metal powders and powder metallurgy; and electronic cores.

Embrittlement by Liquid Metals. *W. Rostoker, J. M. McCaughey and H. Markus. Reinhold Publishing Corp., New York. 1960. Cloth, 6 by 9 in., 162 pp. Price $7.95*

A new approach to embrittlement by liquid metals based on modern dislocation theories of brittle fracture. The book explains the relationship between environment and high and low melting metals and the frequency and severity of embrittlement.

Subjects covered include: occurrence of liquid metal embrittlement; crack propagation; factors influencing embrittlement; delayed failure in liquid metal embrittlement; theory of fracture of metals; and mechanism of liquid metal embrittlement.

In addition, the authors have collected, reviewed, and evaluated the

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Tempilstik°—a simple and accurate means of determining preheating and stress relieving temperatures in welding operations. Widely used in all heat treating—as well as in hundreds of other heat-dependent processes in industry. Available in 80 different temperature ratings from 113°F to 2500°F . . . $2.00 each.

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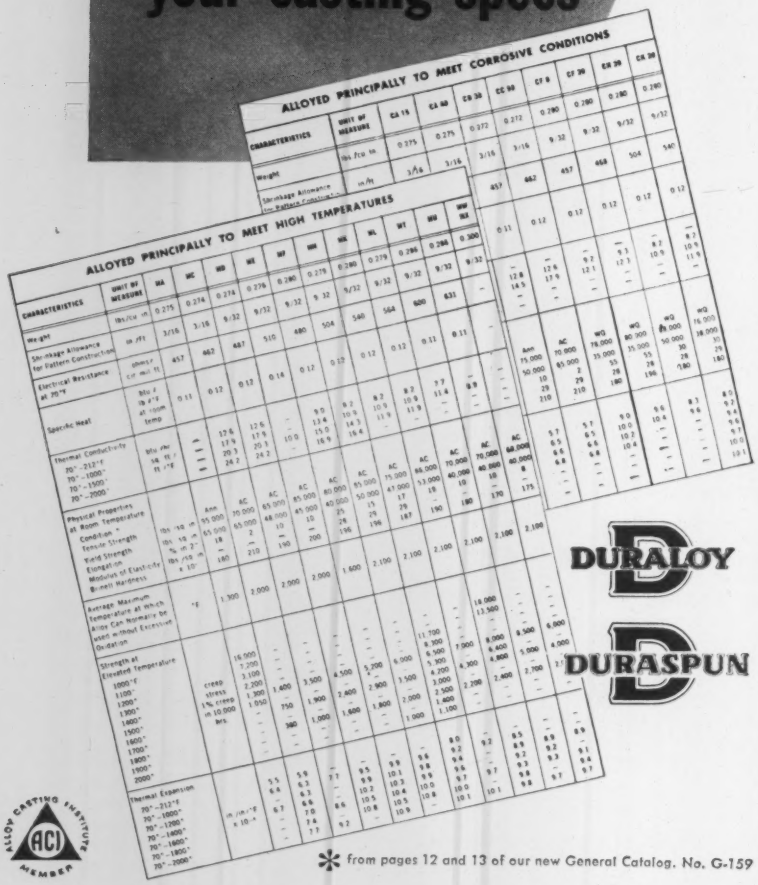
TABLES to help you select the proper alloy for your casting specs



DURALOY

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ALLOY CASTING INSTITUTE (ACI) MEMBER

* from pages 12 and 13 of our new General Catalog. No. G-159

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

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OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23908 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 426

TECHNICAL LITERATURE

vast amount of information on embrittlement by liquid metals which heretofore has been scattered throughout the literature. They have also included previously unpublished results of latest research in the field.

Reports

Protective coatings DEVELOPMENT OF PROTECTIVE COATINGS FOR REFRACTORY METALS. *C. G. Goetzel and others. New York University. Feb. '60. 57 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.50 (PB 161736)*

Indications are that tungsten wires can be protected against oxidation in stagnant or flowing air at temperatures up to 3000 F for periods up to 20 min by applying a multilayer coating of chromium, silicon and rhodium. Further improvements can be made if complete diffusion alloying, bonding, and melting of the surface coat is achieved over the entire length of the specimen.

Beryllium casting BERYLLIUM RESEARCH FOR DEVELOPMENT IN THE AREA OF CASTING. *F. A. Crossley and others. Armour Research Foundation. Feb '60. 102 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25. D. C. Price $2.50 (PB 161754)*

A study made to explore the possibility of developing sound, fine-grained cast beryllium showed 1) the occurrence of a pronounced thermal arrest about 40-50°F below the solidification temperature of beryllium, 2) the existence of transformation markings, and 3) the lack of a preferred orientation for columnar grains in cast beryllium. Several experiments indicated promise: one ingot, cast under vibration at 5 g acceleration and 60 cps, showed substantial zones of relatively fine, equiaxed crystals.

Predicting service life LABORATORY TEST PROCEDURES FOR PREDICTING THE TROPICAL-SERVICE LIFE OF ELECTRONIC COMPONENTS AND MATERIALS. *Available from Dept. of Commerce, Field Services, 350 Fifth Ave., New York 1, N.Y. Price $2.75*

Contains a summary of data obtained from over three years' exposure to tropical environments of a wide variety of electronic components.

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for Jet Spray Cooler . . . PLEXIGLAS® acrylic plastic is used for sparkling transparent bowls and lids on cold drink dispensers. Bowls and lids are one-piece moldings—crystal clear, breakage-resistant and free from taste or odor. Seven-inch-deep bowls measure 17″ by 14″.

for Smith-Corona . . . IMPLEX®, the tough, rigid, high-impact acrylic, gives outstanding strength and stain-resistance to vital components of new Galaxie portable typewriters. In addition, the smooth surfaces and lustrous colors of the IMPLEX parts contribute to the typewriter's handsome appearance.

for you . . . PLEXIGLAS and IMPLEX can give your products added utility and sales appeal. Our design staff will be pleased to help you use these Rohm & Haas molding materials—to your advantage.

ROHM & HAAS

PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill, Ontario*

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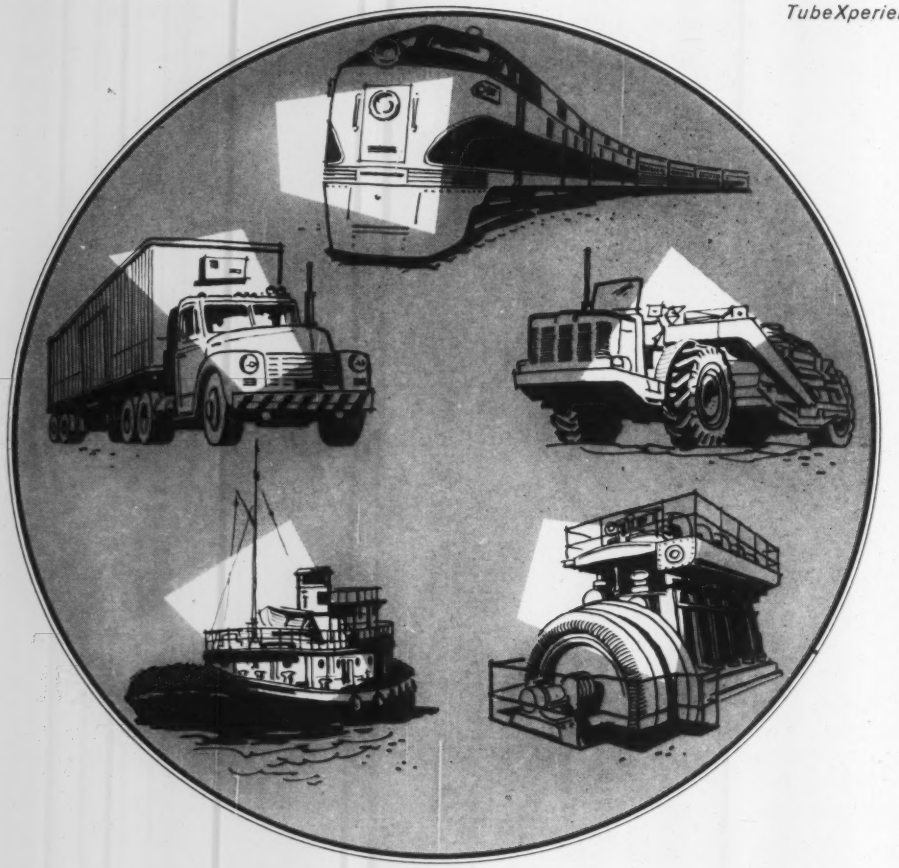

Feedlines for hungry horsepower . . . diesel fuel injection tubing by Superior

Fuel injection systems are the heart of thousands of diesel-powered trucks, locomotives, roadbuilding equipment, electric generators, and marine power plants. The tubing that conveys the fuel from injection pump to nozzle assembly is an important component. It must resist the stresses of pressure and vibration, yet be ductile enough to be cold swaged and upset and be cold formed into loops and bends without excessive springback. It must have a clean ID, tremendous burst strength, and high fatigue resistance. Superior diesel fuel injection tubing is just such a premium product.

Type C-1008 and Type MT-1010 carbon steel tubing are most commonly specified for this application, but alloy and stainless steel tubing for pressures above 9000 psi and greater corrosion resistance is available. Superior also makes tubing for many other applications—supplies both general and special purpose tubing for aircraft, missiles, electrical, electronic, chemical, hydraulic, dairy and nuclear, to name a few. For complete information, write Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

SOME REASONS WHY SUPERIOR FUEL INJECTION TUBING IS A PREMIUM PRODUCT

- It will handle pressures to 9000 psi, is hydrostatically tested to various pressures according to specification
- It is cold drawn, dead soft annealed, and seamless
- It is ID conditioned to remove fissures and other defects
- It is free from ID radial cracks deeper than .005 in. or 5% of wall thickness, whichever is less
- It is annealed at finish in controlled atmosphere furnaces to produce a soft, ductile and scalefree material
- Fracture tests are performed when requested

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The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

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Ameripol Rubber takes to color, like a duck...

The manufacturers of these various rubber products leave color masterbatch compounding to an expert: Disco, Incorporated, of Butler, New Jersey. Disco uses an Ameripol rubber polymer from Goodrich-Gulf since experience has shown its exceptional uniformity, and excellent dispersion characteristics. This simplifies color compounding—and with pigments costing up to 30 dollars a pound, variations can't be tolerated. In addition, Goodrich-Gulf service... in convenient warehousing, dependable delivery, and technical assistance, contributes to an efficient operation. For complete service, come to the world's largest source of synthetic rubber. Goodrich-Gulf Chemicals, Inc., 1717 East 9th Street, Cleveland 14, Ohio.

Ameripol
THE PREFERRED RUBBER

Goodrich-Gulf Chemicals, Inc.

THE ONE TO WATCH FOR NEW DEVELOPMENTS

For more information, turn to Reader Service card, circle No. 359

BOND FAILURES CAN BE PREVENTED!

Here's how to stop 13 of them...

Type of Failure	Solution
THERMOSETTING ADHESIVES	
• Cohesive failure	Check film with solvent used in adhesive. If solvent softens the adhesive film or becomes tacky, this indicates insufficient cure. Make sure bond line time and temperature is used.
• Adhesive failure from metal	If metal surface has a white, clean appearance, check cleaning technique.
• Adhesive failure from substrate other than metal	Try prime coat of diluted adhesive, also check compatibility.
• Cellular areas in adhesive line	Increase pressure and/or adhesive.
CONTACT ADHESIVES— room temperature setting	
• Tacky film	If film should dry hard but remains tacky, the cause may be entrapped solvent or migration of plasticizer from one substrate.
• Shiny areas	Poor contact, insufficient pressure or insufficient amount of cement.
• No bond	If heat reactivated type, adhesive was too cool at time of assembly or poor compatibility.
• Failure in adhesive from metal	Improper cleaning.
• Failure from substrate other than metal	Incompatible or unclean surfaces.
HOT MELT	
• No bond	Incompatibility, adhesive too cool at time of assembly. Parts too cool at time of application of adhesive.
EPOXY BASE ADHESIVES AND CASTING COMPOUNDS	
• High exotherm	Mix lower volume and pour mixed material into shallow tray. Cool base and activator before mixing or use Metermixing equipment.
• Tacky film or casting	Improper base activator ratio, improper mixing of base and activator, improper cure. Check bond line temperature.
• Flexible casting or film of rigid adhesive or casting compound	Improper mixing of base and activator, improper base and activator, improper cure. Check bond line temperature.

Bond failures can be prevented! Raybestos-Manhattan's adhesive experts also have solutions to less common causes of bond failures . . . based on more than 20 years' experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on them today for the answers to your adhesive problems—no cost or obligation, naturally.

R/M Bulletin No. 700 is packed with helpful technical information on Ray-BOND adhesives. Write for your free copy now.

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT, Bridgeport, Conn. • Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

R/M

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For more information, circle No. 431

Photograph taken with the cooperation of Pretty Products, Coshocton, Ohio, and The Ceramaflex Division of U. S. Ceramic Tile Company, Canton, Ohio.

PLIOFLEX takes the stumbling block out of new flooring

The idea was a natural — ceramic tiles for flooring set in 9"x9" rubber grid sheets. It opened new markets, suggested myriad designs. And it would make flooring resilient, quiet, easy on the feet, easy and economical to install.

The stumbling block: finding a low-cost rubber that wouldn't deteriorate and discolor with age.

Then a leading manufacturer tried PLIOFLEX 1773. Its cost was right. So were its physical properties. And its good color retention and ultraviolet resistance licked the age-color obstacle. What's more, PLIOFLEX offers top processing ease, maximum uniformity and outstanding molding characteristics. Result? Fewer rejects — more profit.

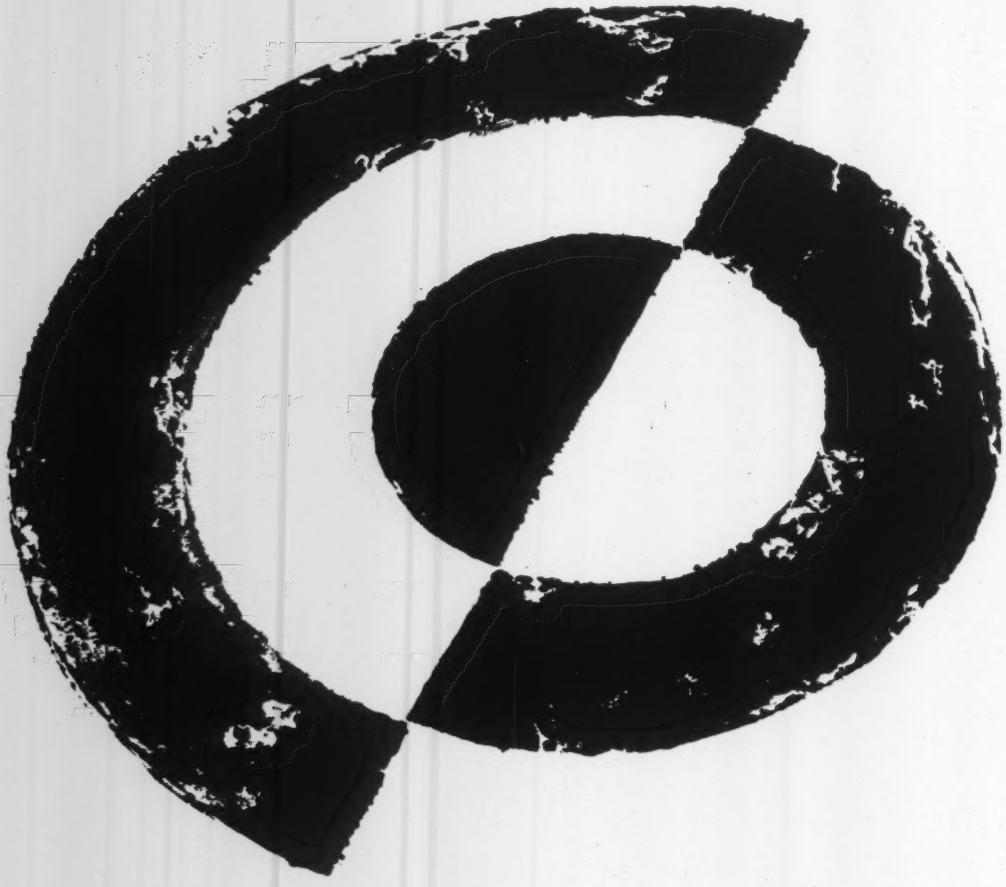
If you want to invade a new market or improve an old product, look into PLIOFLEX. For full details and outstanding technical help, simply write Goodyear, Chemical Division, Dept. B-9437, Akron 16, Ohio.

Lots of good things come from

GOODYEAR

CHEMICAL DIVISION

Plioflex—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio



Said J. Stefan and L. Boltzmann: *"The total radiation from a black body is proportional to the fourth power of the absolute temperature of the black body."*

Radiation is usually associated with high temperatures. Yet very cold bodies emit a radiation which can be highly significant in missile and space applications. The problem faced by infrared scientists, trying to detect variations in radiation from low temperature atmospheres, can be likened to detecting a one-foot cube of ice from a distance of five miles.

Lockheed Missiles and Space Division scientists are deeply engaged in studying the problems of infrared emission from the earth and its atmosphere, as seen from orbital altitudes. Although the earth resembles a black body at 300° Kelvin, the emission from its atmosphere, under some circumstances, is much colder. To make measurements under these circumstances, Lockheed has evolved radiometric equipment with one of the most sensitive detection systems yet conceived.

Scientists and engineers must also take careful measurements of a potential employer. Lockheed Missiles and Space Division in Sunnyvale and Palo Alto, California, on the beautiful San Francisco Peninsula, invites this close scrutiny. As Systems Manager for the DISCOVERER and MIDAS satellites and the POLARIS FBM, Lockheed preeminence in Missiles and Space creates positions in many disciplines for outstanding engineers and scientists.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-13F, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

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CELLULOSE PROPIONATE

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POLYESTER RESINS

Acetate, Propionate and Triacetate
CELLULOSE FLAKE

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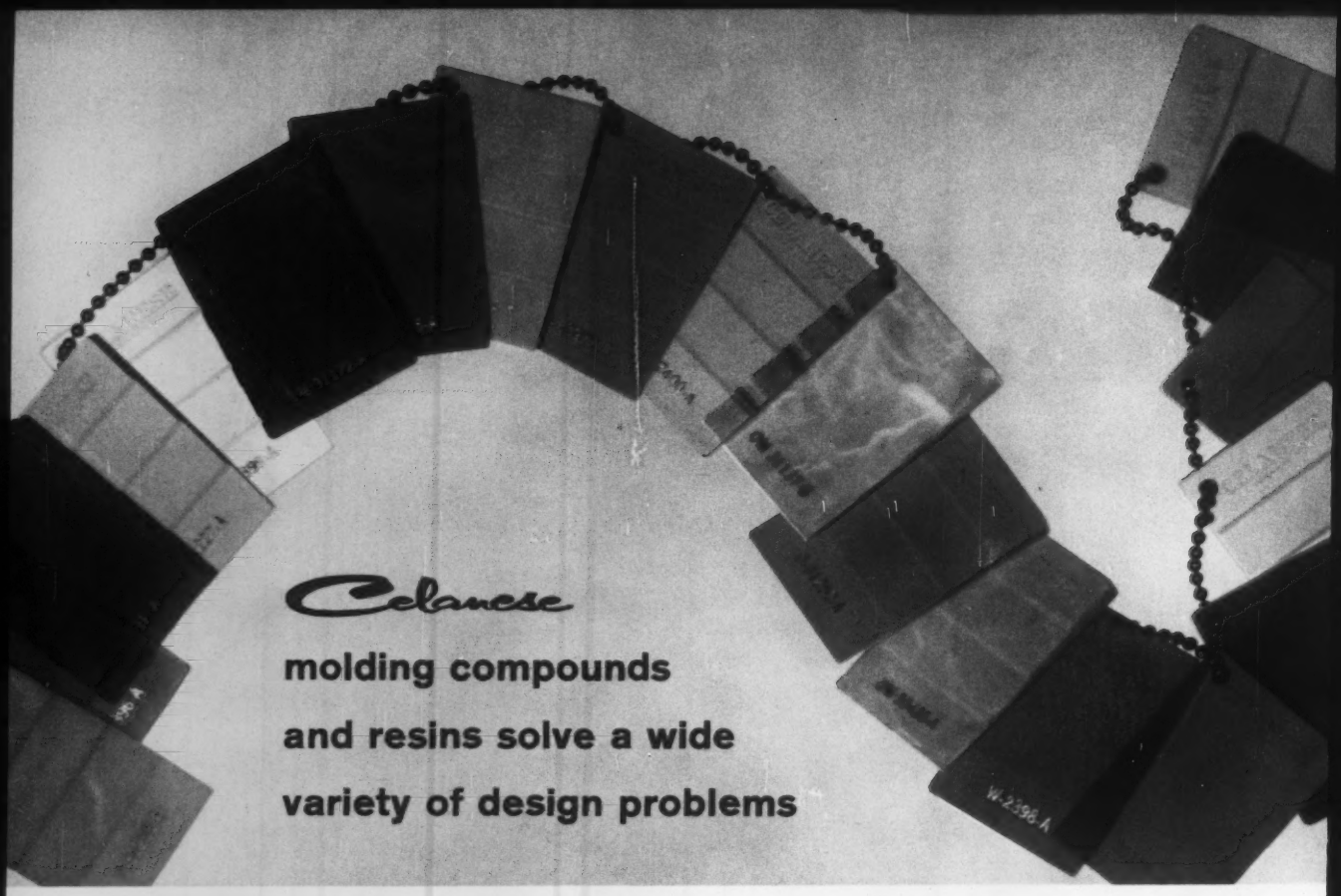
TECHNICAL SERVICE



FORTIFLEX . . . A Complete Range of Polyethylenes

Resins ranging from high to low density. There are four basic Fortiflex types: Series A, B, C, and D. Fortiflex A and B available in natural or scientifically color-matched to your specifications. Fortiflex C and D available in natural only. Applications: housewares, appliances, automotive and electrical parts, wire insulation, pipe, toys, containers, paper coating, film and sheet.

FORTICEL . . . Cellulose Propionate

Outstanding among thermoplastics for its excellent balance of properties, Forticel meets the demands of a number of automotive and appliance applications. Forticel has excellent dimensional stability, toughness, surface permanence and moldability, and is free of objectionable odor. Applications: automotive steering wheels and decorative trim, appliance and telephone housings, brush backs, dials, knobs and blow molded products.

ACETATE . . . Cellulose Acetate

Rugged, versatile, economical, Celanese Acetate is unequalled for its combination of toughness, clarity and price. It is available in a wide range of formulations and flows—in a limitless variety of scientifically matched colors. Applications: shoe heels, appliance housings, jewelry, tool handles, toys, sun glass frames, brush backs, houseware items and blow molded products.

POLYESTER RESINS

Here are the properties that speed production, cut down rejects. Celanese Polyester Resins offer fast cure, low drainage, better wet-out in hand lay-up. They are unequalled for saving time and labor on critical large area moldings. And they are outstanding for formulating and molding pre-mix and matched die patts. Applications: Boats, refrigerator doors, truck bodies, cooling tower grids, automotive and appliance parts, electronic housings, and decorative items.

CELLULOSIC FLAKES

Celanese offers cellulose acetate, cellulose triacetate and cellulose propionate flake in a variety of grades to basic industries such as plastics, sheet, film, fibers, protective coatings and adhesives. Specific applications include lacquer for paper, wire, and flashbulb coatings; film and sheeting for photography, graphic arts, and transparent packaging; molding powder for extrusion and injection molding of tool handles, tubing, and toys; and binders for color concentrates.

CELANESE TECHNICAL SERVICE

Celanese has the engineering staff to help you get the most out of plastic materials at any stage from design to finished product. This service includes: design consultation, assistance with mold design, material selection, equipment and its adaptation, pilot molding supervision and product testing.

The Celanese Technical Service Laboratory is one of the finest of its type. It is complete with actual production equipment, color matching departments, and analytical and physical testing laboratories. For the right answers to problems of plastic application, or technical information on specific plastic materials, write: Celanese Polymer Company, Dept. GK-11, 744 Broad Street, Newark 2, New Jersey.

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Celanese Polymer Company is a Division of Celanese Corporation of America.
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
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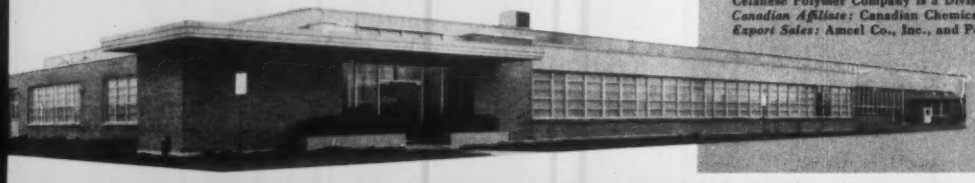

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PLASTICS

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its live fibres combine nature's best with the laboratory's latest...

They repel water, stop rust, reduce friction, resist abrasion, stand 300° F. heat or −65° F. cold. Hard or soft, their wondrous interlocking fibers go on flexing, filtering, wicking or wiping long after other materials break down.

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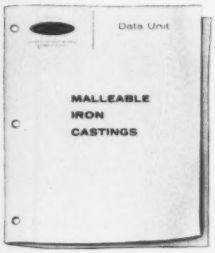
New Cars and Trucks Use More Malleable For Better Performance...Lower Cost

As the automotive industry steps up its drive to pack greater performance into lighter weight vehicles and still hold costs in line, the demand for Malleable iron castings continues to increase. Noted for their strength, toughness, machinability and economy, Malleables are used as key components in every make and type of vehicle.

Matching each new advance in automotive technology, Malleable is now available in a broad range of properties, including tensile strengths from 50,000 to 120,000 psi!

Find out now how much Malleable castings can improve your products. Contact any company that displays this symbol —



For Free Literature on advantages of Malleable iron castings, with examples from the automotive industry, ask any member company for Data Unit No. 113, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

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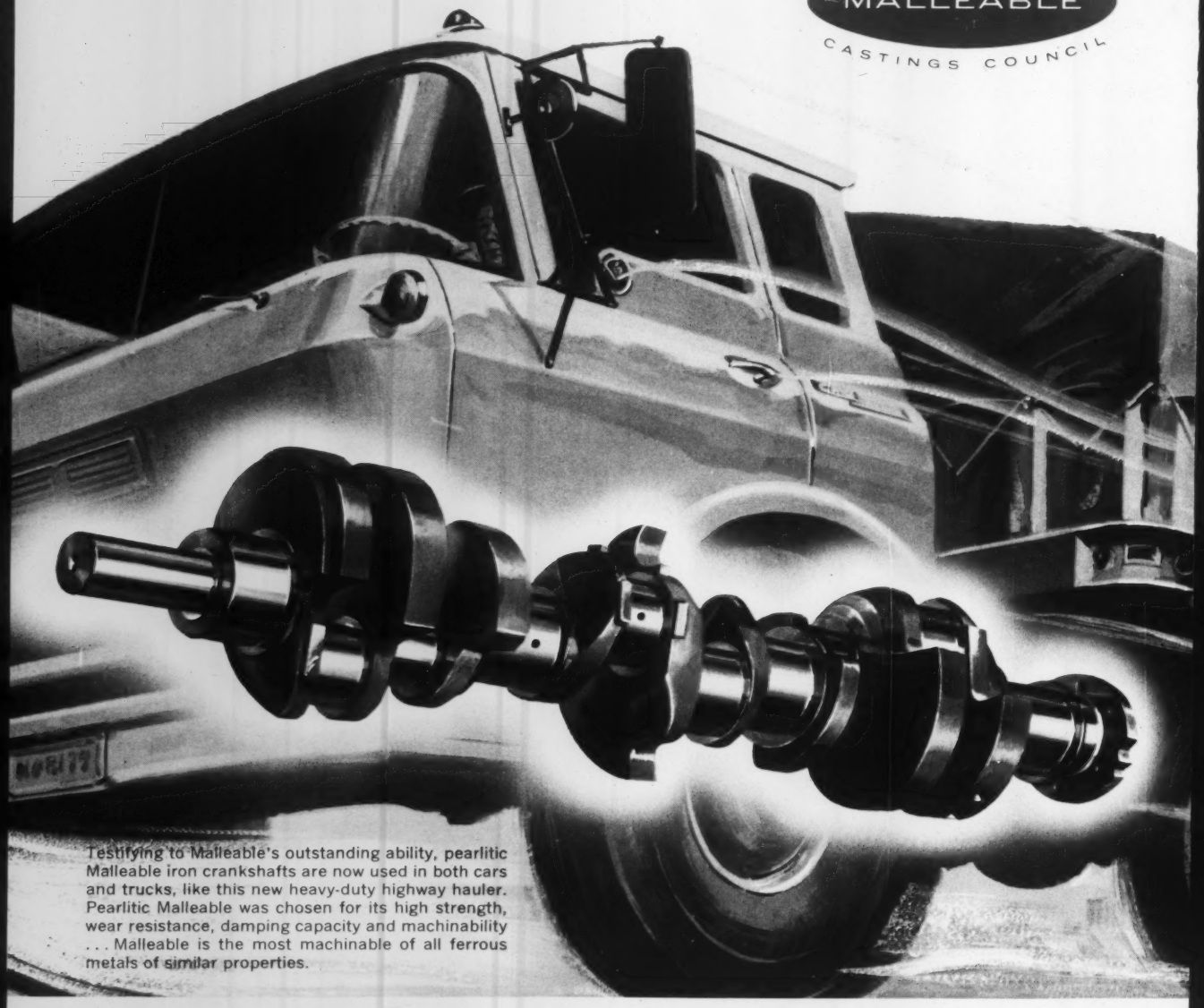
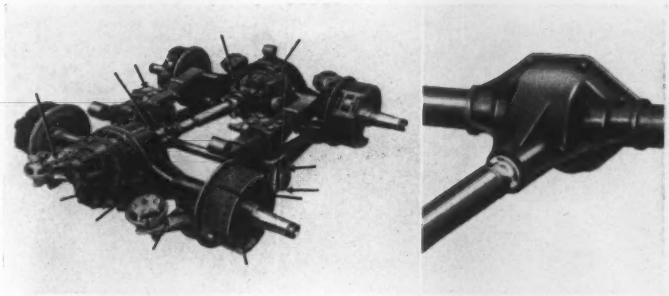


Testifying to Malleable's outstanding ability, pearlitic Malleable iron crankshafts are now used in both cars and trucks, like this new heavy-duty highway hauler. Pearlitic Malleable was chosen for its high strength, wear resistance, damping capacity and machinability . . . Malleable is the most machinable of all ferrous metals of similar properties.

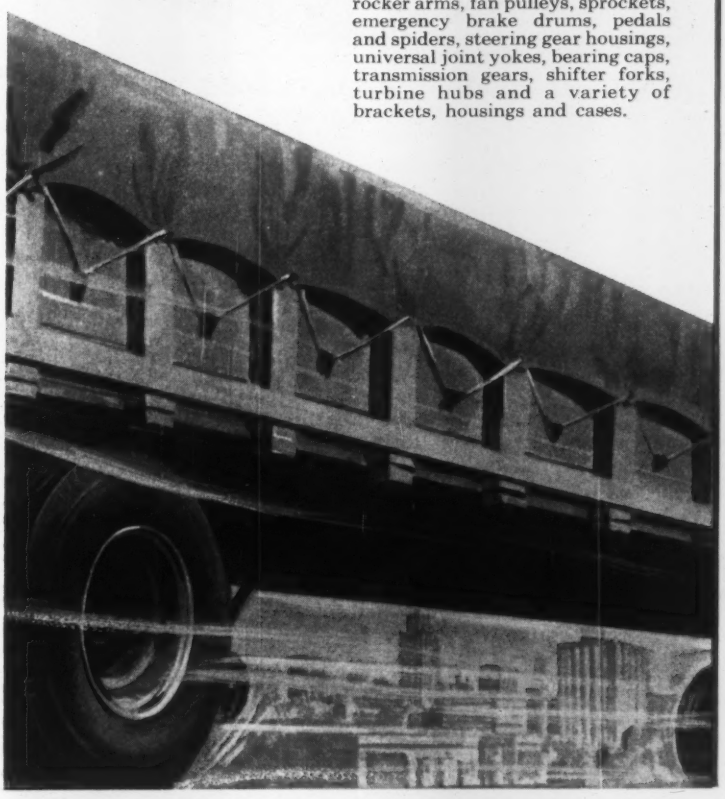


From the smallest cars to the largest trucks, all American vehicles rely on Malleable for a range of uses. In this tandem axle, for example, a total of 36 parts is Malleable.

Malleable differential carriers form the backbone of the rear axles on many new compact cars, as shown at the right above. Tubular steel extensions are pressed into the Malleable housing where they are "puddle" welded. Decisive factors in Malleable's selection were strength, economy, ease of machining and ability to be produced in a design that required a minimum of tooling expense.

The increasing conversion from other materials to Malleable castings for all kinds of parts from crankshafts to door hinges is adding momentum to the automotive industry's steadily increasing use of Malleable.

Among the many Malleable iron castings in this composite car are torsion bar arms and brackets, rocker arms, fan pulleys, sprockets, emergency brake drums, pedals and spiders, steering gear housings, universal joint yokes, bearing caps, transmission gears, shifter forks, turbine hubs and a variety of brackets, housings and cases.



For Quality and Economy Use

MALLEABLE

For Service Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

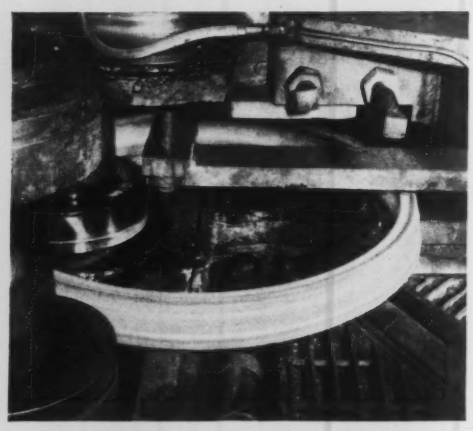
TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

These companies are members of the Malleable Castings Council

For more information, turn to Reader Service card, circle No. 343



Manufacturer uses ring-roller to shape turbine seal rings made of HASTELLOY alloy X

The surging power of modern 20,000-pound thrust jet engines is being harnessed effectively by critical parts made of HAYNES high-temperature alloys. Turbine seal areas are typical of the hot spots in which these alloys serve. Here, in the form of turbine seal rings, they contain the hot combustion gases as they roar through the various turbine stages.

In these, and in other parts too, such as afterburner liners, flame holders, shrouds, and investment-cast turbine blades and nozzle vanes, HAYNES alloys are resisting the punishing effects of long hours at high temperature. In fact, one of the Air Force's latest 1500-MPH jets uses six different HAYNES alloys in vital parts where heat and stress would weaken and fatigue other materials.

Whether investment- or sand-cast, rolled, wrought, vacuum melted, or air melted, there's a HAYNES high-temperature alloy to meet your needs.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, N.Y.

"Haynes," "Hastelloy," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 374

PRODUCT-DESIGN BRIEFS FROM DUREZ

- What a solvent cement can do
- Something new in electrical insulation
- A bulletin on plastics

Stuck?

A good adhesive does a lot more than stick two things together. You can use

today's solvent-type adhesives to:

- smooth out surface contours (as in brake linings and in jet aircraft skins, where adhesives can eliminate the need for projecting rivets);
- distribute stress uniformly over a surface, rather than concentrating it at welded or riveted points;
- build up large structural members from many small components;
- reduce galvanic action between dissimilar metals, and so lessen the risk of corrosion.

One super-sticker in this class sets with only contact pressure and at room temperature; adheres very well to metal, wood, phenolic laminates, glass, and rubber. Block shear tests show 4500 psi at room temperature, and tensile strength is 10,000 psi. The cement has excellent resistance to all ordinary solvents, water, oils, alkalies, and acids; has high capillary attraction and does not shrink.

We don't make adhesives. We do make heat-setting phenolic resins that give many of the newer adhesives more gripping power and more *permanence*. Next time you have a fastening problem, give these new solvent-type adhesives a chance to show you what they can do.

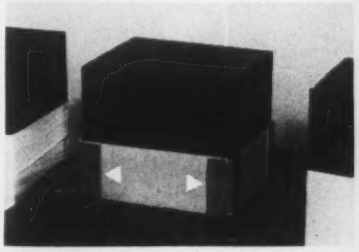
Stock insulation shapes

This insulation idea solves three engineering problems at once in a dry-type transformer. You'd find the same approach helpful in a circuit breaker, a panel, or other heavy-duty electrical gear.

See the plastic angle pieces (below)? They insulate the corners of the laminated steel core from the windings, at the high-stress areas. They take the place of roll-formed fiber. Advantages:

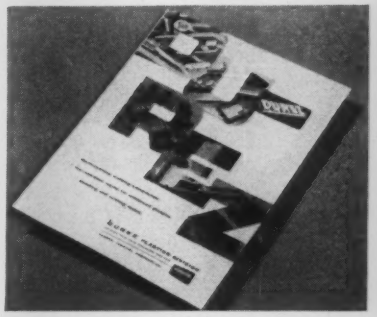
1. Greater mechanical strength. This ends cracking or breaking of insulation when windings are forced into position.
2. Better resistance to moisture. The insulation doesn't swell or shrink, maintains its dielectric strength under the clammiest conditions.
3. Higher heat resistance. The angle is made with glass-reinforced Hetron,® our inherently heat-resistant polyester resin. It meets NEMA GPO-1 specifications, and has UL-recognized flame retardance. It is designed for equipment operating at Class B temperatures (266° F.).

Now for the clincher. You can get flame-retardant structural insulation like this *from stock*—in a wide range of cross-section shapes including channels, in widths up to $9\frac{21}{32}$ inches, lengths to 76 inches.



PRECISION WELDER AND FLEXOPRESS CORP.

You get them not from us but from the manufacturer, The Glastic Corporation, 4321 Glenridge Road, Cleveland 21, Ohio. The Glastic people will be glad to send you details on stock channels and angles if you write to them.



Facts without a file

What does a man do when he wants to know more about Durez plastics?

He looks in Sweet's File. There he finds eight pages packed with the what, how, when, where, and why of using Durez materials—phenolic and diallyl phthalate molding compounds, Hetron polyester resins, phenolic resins.

What if he hasn't got Sweet's File handy? He sends us the coupon below, requesting Durez *Bulletin D400*. The same fact-filled eight pages come to him posthaste.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic resins (12-page bulletin listing applications)
- ☐ Hetron fire-retardant polyester resins (data file, including names of fabricators)
- ☐ Durez plastics *(Bulletin D400)*

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead)*

DUREZ PLASTICS DIVISION

1402 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 400

Portable "service center"

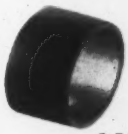
Hundreds of companies have saved money, improved products and cut production waste as the result of opportunities presented by the Ryerson "Metalogikit."

How? This unique kit is a veritable portable service center... lets you explore many alternatives to material you now use. For example, you can compare several different cutting methods on the same piece of steel to see which is best for your application.

Following are a few random examples showing how Ryerson specialists, using the Metalogikit, have helped customers with a variety of problems—many similar to those you may face every day.

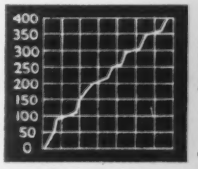
If you would like to put the Ryerson Metalogikit to work for you, call your Ryerson representative for a demonstration—for unbiased recommendations on steel, aluminum, plastics and metalworking machinery.

sparks new ideas and savings



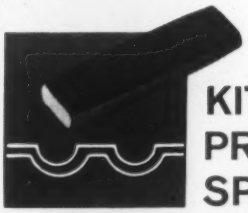
KIT SPOTS SAVINGS

Scratches and grooves normal to cold drawn, seamless tubing caused high manufacturing costs for a company making small, light-wall hydraulic cylinders. The small I.D. had to be honed to eliminate these faults—often too much metal was removed for proper piston fit. A Ryerson specialist suggested a switch to *welded tubing*. Using a sample from his Metalogikit, he pointed out the better finish that eliminates expensive honing. The switch was made with these results: higher production, low reject rate, improved product—plus lower purchase price per foot of tubing.



METALOGIKIT TURNS UP 400% PROFIT

Bidding on a routine job was delayed for one steel fabricator because of an unusual material requirement in the specs—calling for an insulating block of phenolic laminate. For help, the company turned to its Ryerson representative, who showed a sample of Ryertex® sheet stock from his Metalogikit. In addition to having the material available from stock, he was able to show how easily it could be fabricated. This Ryerson know-how, demonstrated by the Metalogikit, enabled the customer to enter his bid on time. He got the job, and made a 400% profit.



KIT SUGGESTS PROFITABLE SPEC CHANGE

Fractures and rejects were extremely high for a manufacturer cold forming two severe bends in flat, hot rolled bars. A Ryerson specialist examined the ⅜" x 2" bar stock and compared it with a sample of M-1020 flattened round bar from his Metalogikit. He explained how controlled carbon of Ryerson M-1020 bar would produce great cost-saving advantages in this operation over hot rolled, mild steel. After specs were changed to this Ryerson-supplied bar, fractures and rejects were substantially reduced—resulting in new profitability.

STAINLESS FROM KIT LEADS TO SAVINGS

This company had an emergency requirement for stainless sheets. Application had always called for Type 304, 16 ga. x 66" x 81", *polished on one side*. Their Ryerson specialist questioned the need for polishing. From his Metalogikit, he showed them a sample of 304 with a 2B finish. The company readily agreed it was exactly the finish needed *without polishing*—saving delivery time and material cost. The Ryerson man further suggested 16 ga. x 72" x 144", using the cut-off pieces for another job—reducing scrap waste on *both* requirements. Order was placed and delivered in plenty of time. Over-all result: a substantial saving.

METALOGICS
RYERSON PLUS VALUES

STEEL • ALUMINUM • PLASTICS • METALWORKING MACHINERY

RYERSON STEEL

Joseph T. Ryerson & Son, Inc., Member of the INLAND® Steel Family

PLANT SERVICE CENTERS: BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT • HOUSTON • INDIANAPOLIS
LOS ANGELES • MILWAUKEE • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SPOKANE • WALLINGFORD

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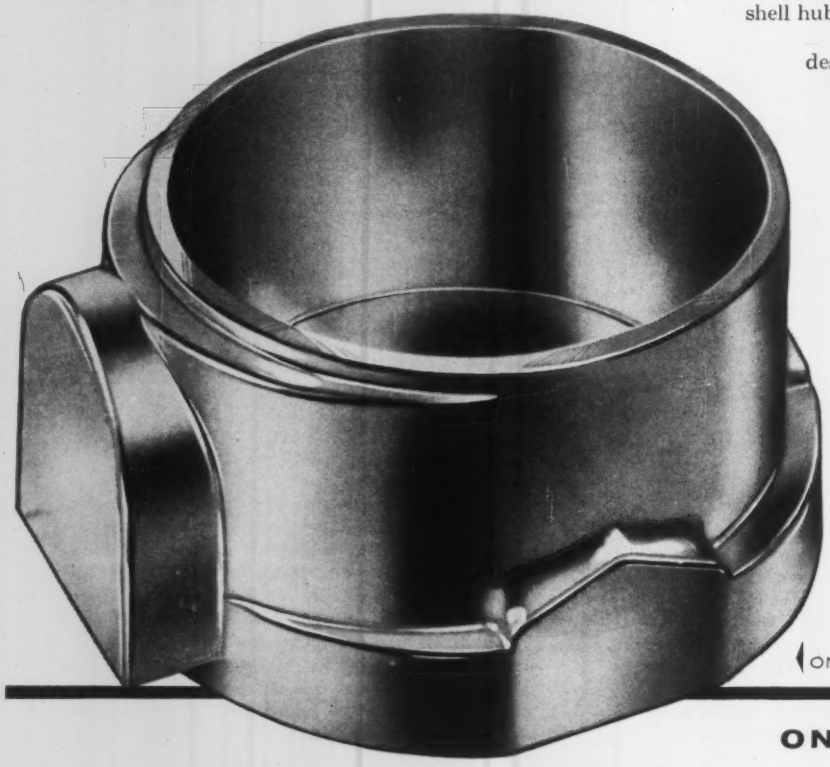
MUELLER BRASS CO. PRODUCES

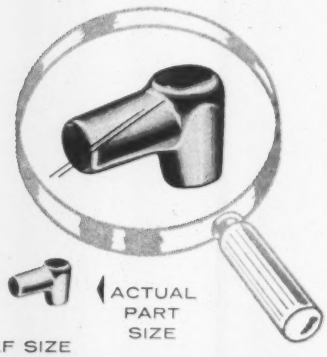
SPECIFICATIONS . . . *REGARDLESS OF*

To obtain the desired physical and design requirements in a part at the lowest cost, there is usually one specific process by which that part can be most successfully and economically manufactured. Because the Mueller Brass Co. offers a variety of production methods, you get sound engineering, accurate production method analysis, our assurance of getting the best product at the lowest cost . . . regardless of metal specified or the size of your particular part.

BRASS, BRONZE, ALUMINUM FORGINGS

The two parts shown here dramatically illustrate the ability of the Mueller Brass Co. to produce precision forgings regardless of size or configuration. Both the tiny dental drill nozzle and the big heat exchanger shell hub, which is the largest of its kind ever produced, were forged to exacting specifications. The weight of the nozzle is only a few ounces while the shell hub weighs 40 lbs., and has a forged pocket 7 15/16" in diameter and 4 3/16" deep. By way of size comparison, the pocket is big enough to hold over 14,000 of these tiny drill nozzles. By forging the pocket, considerable machining time and money was saved. The sound, dense structure of the shell hub makes it ideal for the high pressure application for which it was designed. The forging not only does the job better, but was produced for 25% less than the casting it replaced. Experience makes it possible for the Mueller Brass Co. to produce high quality precision forgings regardless of specifications . . . why not put this experience to work for you?





Write today for Engineering Bulletins on any of these Products.

ONE DEPENDABLE

SCREW MACHINE PRODUCTS

POWDERED METAL PARTS

MUELLER BRASS CO.

PARTS ECONOMICALLY...TO EXACT

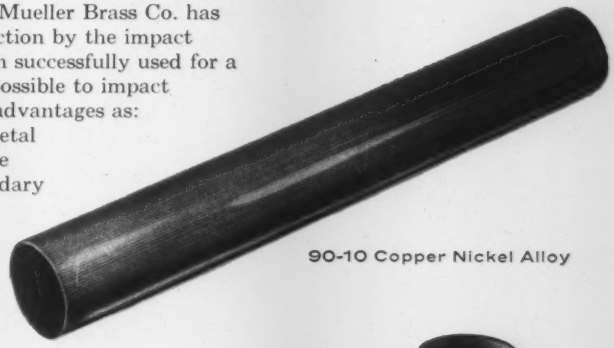
METAL, METHOD OR SIZE...

When you are designing, specifying or purchasing fabricated parts, call in the "Man From Mueller Brass Co." to help lower costs and improve your products. Sales and engineering service is available to you at Mueller Brass Co. offices throughout the United States. Make Mueller Brass Co. your one dependable source for all your part needs.

COLD PREST® IMPACT EXTRUSIONS

Today, because of vast experience in alloys, the Mueller Brass Co. has greatly expanded the possibilities of parts production by the impact extrusion method. Aluminum, of course, has been successfully used for a multitude of tubular shapes. But now it is also possible to impact parts of copper alloys incorporating such major advantages as: closer tolerances, better finish and appreciable metal savings. Because of dimensional accuracy possible with the impact extrusion, the necessity of secondary machining operations is often eliminated.

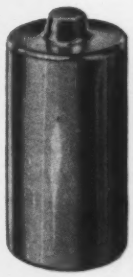
The parts shown here are representative of the group now being economically produced as impact extrusions by the Mueller Brass Co. who offer complete engineering and design service in the development of new parts from copper base alloys.



90-10 Copper Nickel Alloy

Aluminum Alloy 6061

Oxygen Free High Conductivity Copper

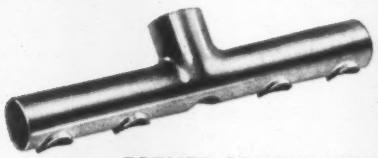


Special Alloy 902

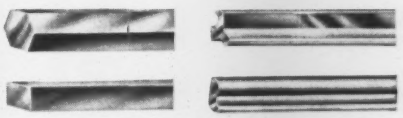
Tellurium Copper Alloy

Low Phosphorus Copper Alloy

SOURCE FOR ALL THESE OTHER PRODUCTS



FORMED COPPER TUBE



STANDARD and SPECIAL ALLOY ROD

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

PORT HURON 21, MICHIGAN

319

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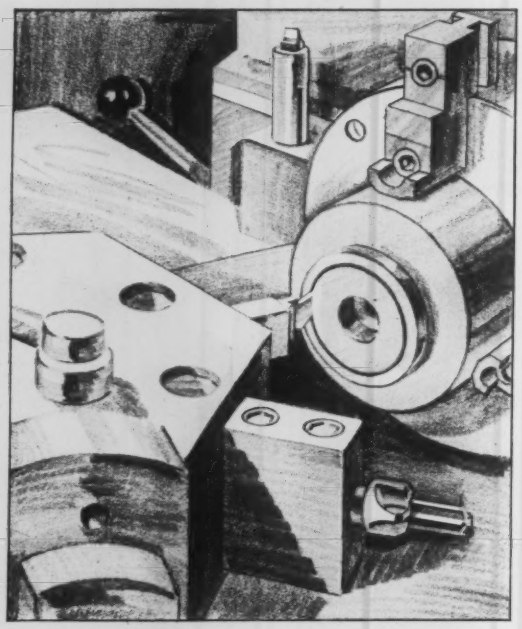
THE FREE MACHINABILITY of EATON PERMANENT MOLD GRAY IRON CASTINGS



Permits Higher Feeds and Speeds, Gives Longer Tool Life

Eaton Permanent Mold Gray Iron Castings are free from inclusions and hard spots, permitting higher machining feeds and speeds, and substantially increasing tool life.

The fine dispersion of graphite and dense, non-porous, homogeneous structure make this an ideal material for many difficult machining operations where high surface finish, accurate dimensional results, and sharp corners are essential. Machining of threads is clean-cut, with good surfaces and no tearing.

Eaton Permanent Mold Iron is recommended for such critical applications as bearing retainers, connecting rods, pulleys, gear blanks, valve bodies, valve plates, hydraulic components, refrigeration and air conditioning parts. Eaton Castings are produced in sizes from 1/10 of a pound to 50 pounds.

When desirable, Eaton Permanent Mold Castings can be hardened to 40-50 Rockwell "C".

CONSIDER THESE EATON ADVANTAGES

- ★ Dense, non-porous, homogeneous structure
- ★ Freedom from inclusions
- ★ Excellent tensile strength
- ★ Ability to take a high surface finish
- ★ Freedom from leakage under pressure
- ★ Uniformity of castings
- ★ Properly annealed; no growth or distortion
- ★ Hardenable to 40-50 Rockwell "C"

Send for Illustrated Descriptive Literature.

EATON MANUFACTURING COMPANY
FOUNDRY DIVISION
VASSAR, MICHIGAN

PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Marine Engines • Marine Drives Pumps • Truck and Trailer Axles • Transmissions • Permanent Mold Iron Castings • Automotive Heaters and Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Forgings • Leaf and Coil Springs • Dynamatic Drives and Brakes Powdered Metal Parts • Gears • Variable Speed Drives • Speed Reducers • Differentials • Centralized Lubrication Systems

For more information, turn to Reader Service card, circle No. 392

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Methods of Carburizing Alloy Steels

Carburizing is a means of impregnating the surface of steel with carbon, usually to very limited depths. Its purpose is to provide a hard, wear-resisting "case," or outer shell. Alloy steels, correctly handled, can be case-hardened without sacrificing desirable core properties.

There are three types of carburizing in general use:

Liquid Carburizing—The medium here is a hot-salt bath composed basically of cyanide compounds. The steel is immersed in the bath, the period of immersion depending upon the analysis of the steel and the depth of case desired. Liquid carburizing is a convenient method of producing thin, hard, wear-resisting cases, generally within the depth range of 0.02 to 0.03 in. However, deeper cases may be obtained, the actual depths depending upon economics and end uses.

Gas Carburizing — This method employs a furnace in which a carbonaceous atmosphere is created; i.e., gases that are high in carbon components, or those containing carbon. Steel subjected to gas carburizing can be case-hardened to depths generally ranging from 0.01 to 0.04 in. When quenching takes place immediately after carburizing, distortion can be kept to a minimum.

Pack Carburizing — Where the pack method is used, the parts to be carburized are buried in a container of dry carbonaceous materials. The container is sealed tight to prevent the infiltration of air, placed in a furnace and kept there for eight hours or more, the actual time depending upon the depth of case desired. Pack carburizing is particularly suitable where a deep case is essential (0.06 in. and over), although medium cases in the 0.04-to-0.06-in. range are possible.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

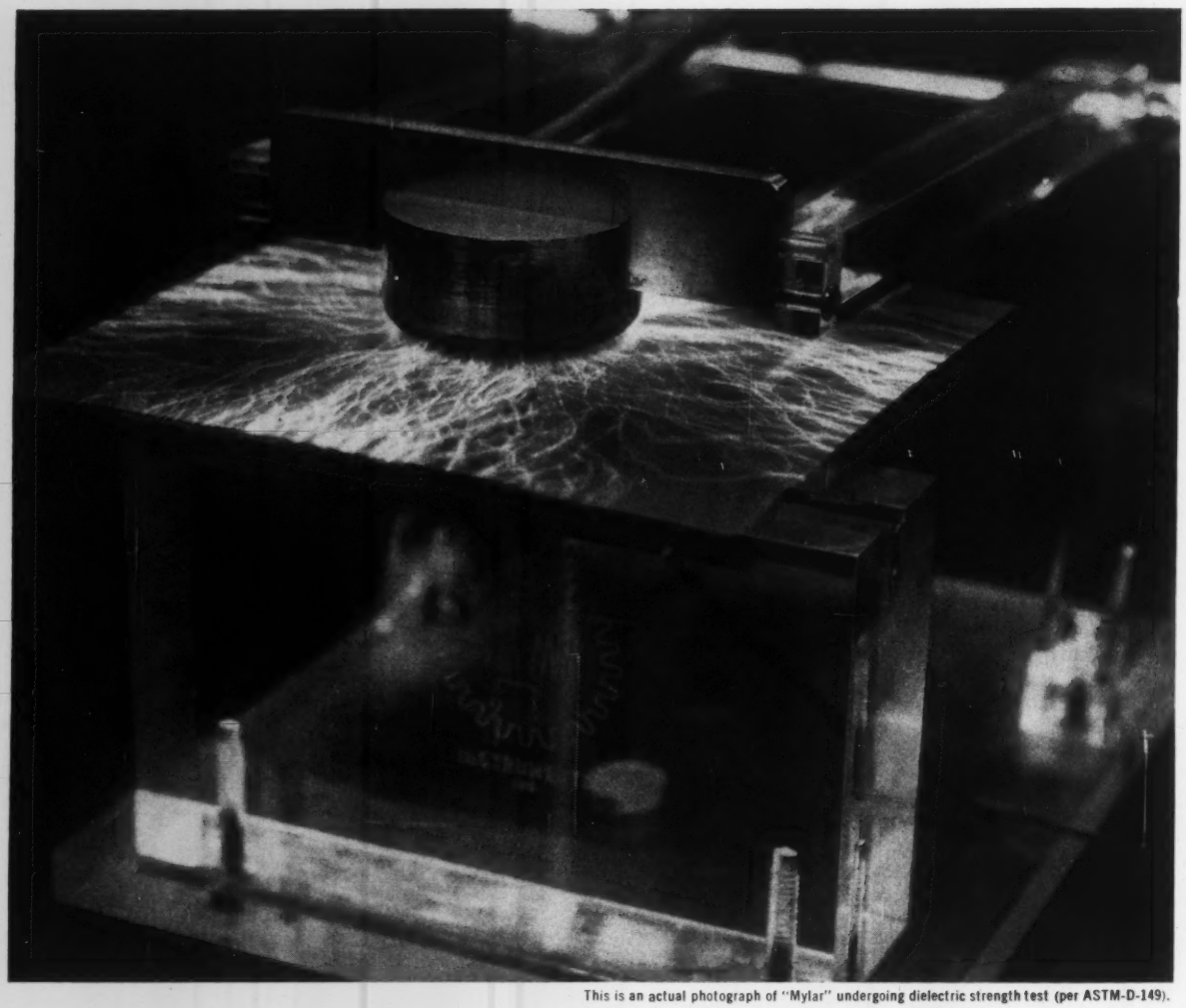
Steel for Strength ... Economy ... Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

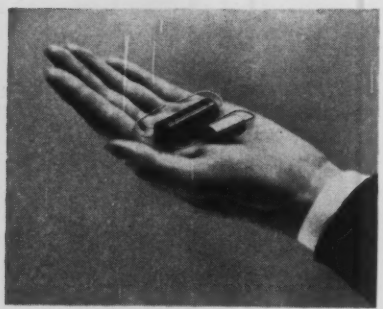
BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 361



This is an actual photograph of "Mylar" undergoing dielectric strength test (per ASTM-D-149).

Can the unique combination of properties found in "Mylar" help you solve your design problems?



High dielectric strength helps cut capacitor size. Tough, thin "Mylar" with a dielectric strength of 4,000 volts per mil for 1 mil film (per ASTM-D-149) permits capacitor manufacturers to reduce size of finished unit . . . improve performance and reliability.

"Mylar"* polyester film is a tough, flexible engineering material. In addition to its outstanding dielectric strength, "Mylar" has an average tensile strength of 20,000 psi, withstands temperature extremes (-60° to 150° C.) . . . resists most chemicals and moisture.

On an area basis, tough, thin "Mylar" often *costs less* than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't embrittle with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the *combination of properties* in "Mylar"® can help you solve knotty design problems, improve product performance or cut costs. Write for our booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Room P-9, Wilmington 98, Del.

*"*Mylar" is Du Pont's registered trademark for its brand of polyester film.*

DU PONT REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

DU PONT MYLAR® POLYESTER FILM

For more information, turn to Reader Service card, circle No. 348

***SICON*®** *the original silicone base heat resistant finish, delivers dependable*

protection AGAINST HEAT

On the **INSIDE** and **OUTSIDE** of High Temperature Combustion Tube Furnaces

Only the finest kind of heat resistant finish satisfies engineers of the Hevi-Duty Electric Company, Milwaukee. The Hevi-Duty Combustion Tube Furnace shown here handles very high temperatures. The sheet steel furnace shell is protected *both on the inside and outside* by SICON in an attractive metallic green, capable of withstanding surface temperatures approaching the 1000°F. range. The inside application prevents rust from forming due to condensation which forms when furnace is initially started. While actual heat loss is minimal, due to highly efficient insulating brick, and by asbestos ends, Hevi-Duty knows from extensive experience that SICON will hold its original color indefinitely, will not chip, peel or powder under actual service use. This marked ability of Sicon to retain its film integrity and color under sustained heat, has made it preferred for scores of other products—manifolds, space heaters, incinerators, even missiles. Send details of your heat problems or fill out and mail coupon today.

Sicon® *Hi-Temperature finish*

by **MIDLAND**
INDUSTRIAL FINISHES CO.
WAUKEGAN, ILLINOIS
Enamels—Synthetics—Lacquers—Varnishes

MIDLAND INDUSTRIAL FINISHES COMPANY
Waukegan, Illinois

Please send copy of latest **SICON** brochure containing complete heat resistant and chemical characteristics and specification details. Dept. B-1.

Firm_____
Name_____
Title_____
Address_____
City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 383

Jet brake cup — LS-53
Synthetic lube diaphragm — LS-53
Diesel equipment seal — Viton
Drop-off tank seal — LS-53
Chemical pump liner — Viton
Natural gas valve diaphragm — Viton

For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling temperature extremes −350° F. to +750° F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excellent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark
**Dow-Corning registered trademark

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVENE DIVISION, 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears

C/R

For more information, turn to Reader Service card, circle No. 349

Cast HT high-nickel alloy conveyor belt still going strong after 8 yrs. service at 1550°F

Resistance to sigma phase embrittlement and thermal fatigue . . . high temperature strength and castability make Type HT* alloy an ideal choice for conveyor belts, baskets, trays and other load-bearing furnace parts.

At one automotive plant, huge 105-ft. conveyor belts—cast of HT high nickel alloy—carry tractor links through continuous, gas-fired hardening furnaces like the one shown above.

And after eight years' service, carrying 3,000 lb. per hour through the 1550°F furnace atmosphere, these conveyor belts are still in operation and expected to give many more years of trouble-free service.

Engineers specified Type HT high-nickel alloy for these parts—for the rollers and idler drums used to rotate them, too—because of this alloy's complete freedom from sigma phase embrittlement, its strength and ductility. These properties, combined with this alloy's casting ease and economy, make it an ideal choice for conveyor belts, baskets, trays and other load-bearing members used in heat treating furnaces.

Wide range of alloys. Type HT alloy is just one of a family of high-nickel alloys available for heat-treating applications. In this family of alloys you'll find metals that provide good strength and long life at temperatures from 1200 to 2300°F. You'll find alloys with remarkable combinations of properties—properties needed to withstand oxidizing and reducing environments, carburizing and nitriding atmospheres.

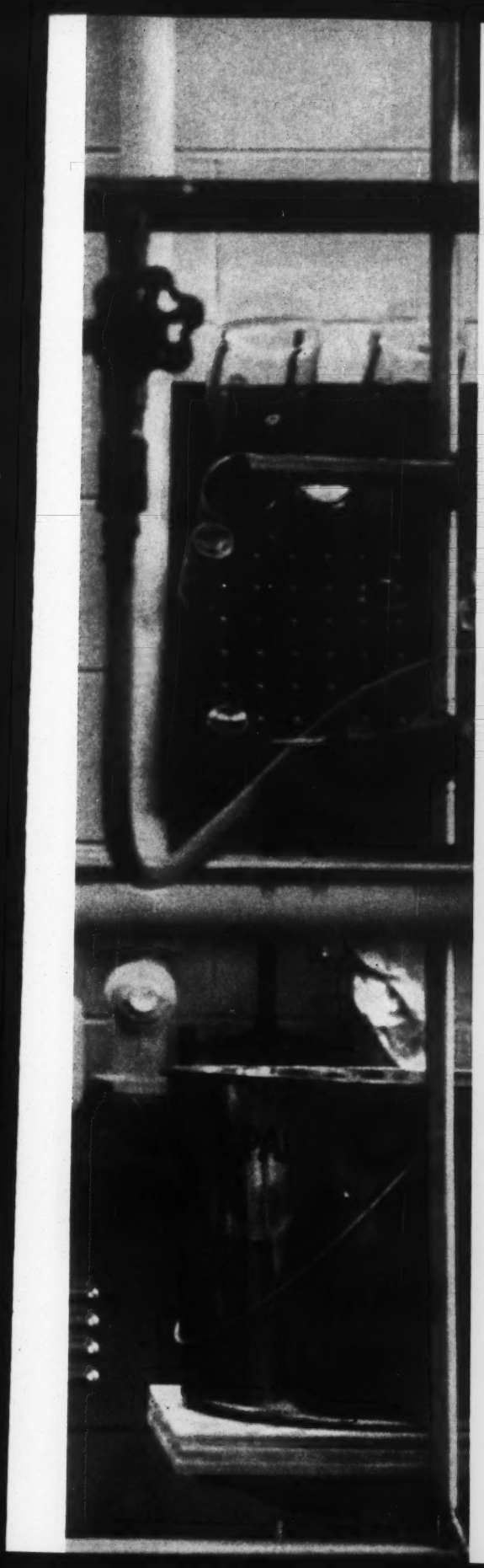
If you have a high-temperature problem, there's a good chance you can solve it with the help of the 72-page booklet, "Heat-Resistant Castings, Corrosion Resistant Castings . . . Their Engineering Properties and Applications." Write Inco for your copy today. Just ask for A-266. *A.C.I. designation

The International Nickel Company, Inc.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES CASTINGS PERFORM BETTER LONGER

For more information, turn to Reader Service card, circle No. 387



Joe Foster considers the scope of Foster Grant's research and development.

"Stereospecific polymerization catalysts may trigger a materials revolution," says Joe Foster

That's what my research and development group tells me. And, we've been giving this area top priority, along with polyamide polymers and co-polymers and graft polymerization.

We know that only through persistent evaluation and re-evaluation can improved resins such as today's general-purpose polystyrene, impact-polystyrene and nylon-6 result. These are the popular-priced plastics that help you produce more efficient, more profitable end-products.

Because we're the world's largest manufacturer of sunglasses, as well as a raw material supplier, we also know that research and development is only part of the answer. During the past 41 years, our combination of raw material and end-product know-how has made us familiar with bulk handling, color matching, machine and mold design—just about every molding problem you're likely to meet.

When you mold with Foster Grant resins, the benefits of this lifetime of successful plastics experience are yours to draw on. Let us show you how we can apply this background to *your* molding operation. Call or write me today at Foster Grant Co., Inc., Leominster, Mass., KEystone 4-6511.

Your Partner in Plastics Progress FG FOSTER GRANT

Plants in Leominster, Mass., Manchester, N. H., Baton Rouge, La.
Branch Offices and Warehouses in Principal Cities
Also distributed by H. Muehlstein & Co., Inc., New York, N. Y.

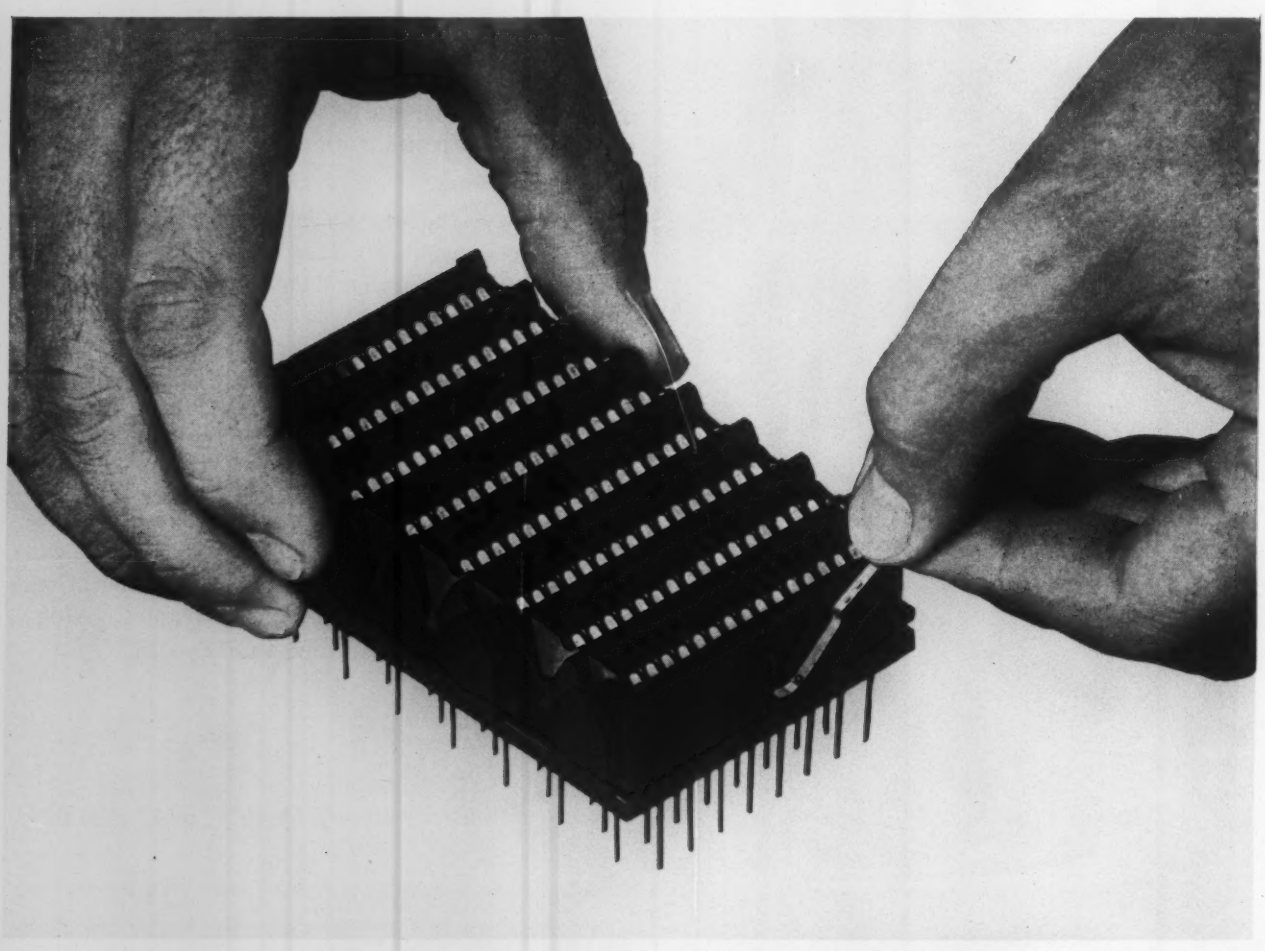
For more information, turn to Reader Service card, circle No. 385

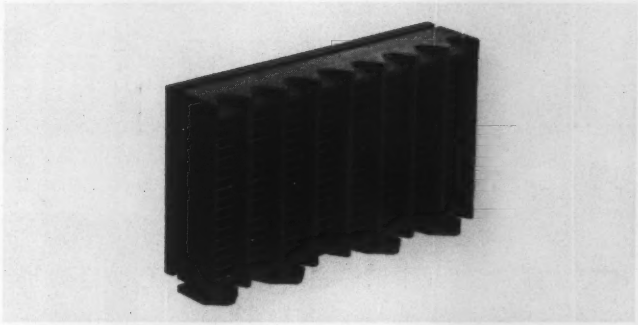
SYLVANIA PRODUCES & DELIVERS THE COMPLETED ASSEMBLY

—at substantial savings to IBM

This electrical connector block is a vital link in the electrical system of an IBM computer. Unless it is built to exact tolerances, the computer can malfunction.

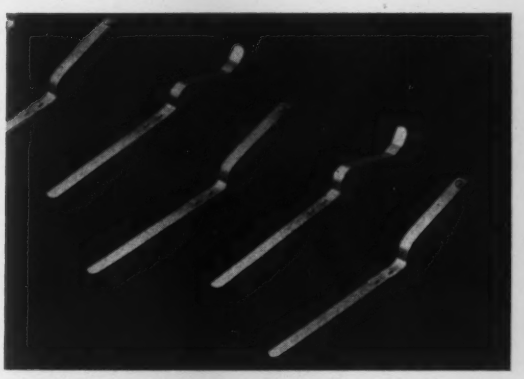
To make this critical part, IBM chose Sylvania because we could perform the entire production sequence—from raw materials to completed assemblies built to tolerances in terms of thousandths of an inch. It soon proved the Sylvania experience paid off in two ways: in production economies and in fast delivery too. Total result: a better connector block—at lower cost. (For details see captions to pictures on these pages.) For full information on how Sylvania custom facilities can benefit *you*, or for a quote on a specific project, write Sylvania Electric Products Inc., Parts Division, Warren, Penn.





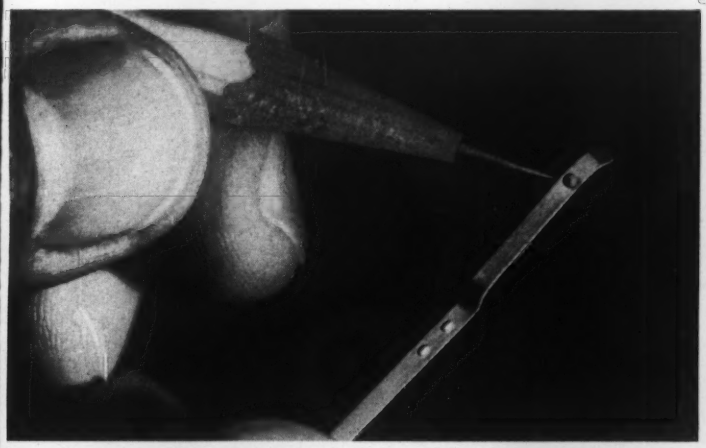
MOLDED FROM PLASTIC by Sylvania, the IBM connector block meets tightest specifications. This is possible because Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment. This equipment permits Sylvania to handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to IBM? Precisely formed parts to fill high-volume requirements.

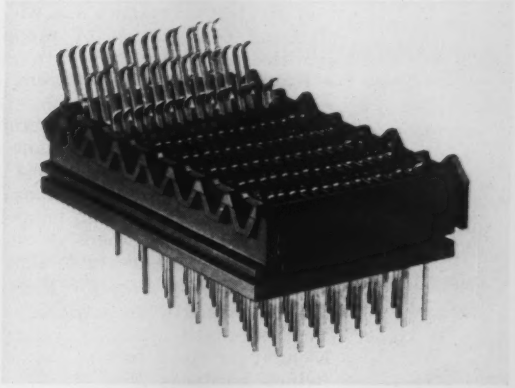


MADE FROM SYLVANIA WIRE, precision-rolled ribbon connectors offer high reliability when the circuitry is completed using wire wrap contact methods. The cross section of the ribbon—.023″ x .062″—and the corner radius of .003″ were accomplished on a special three-head tandem rolling mill and special forming equipment.

Result of this flexibility to IBM? Top reliability at close tolerances.



CUSTOM METAL STAMPING AND DOT WELDING, in one operation, also paid big dividends to IBM. The original plans called for forming parts and then gold-plating the entire contact. Following a request by IBM to extend contact life and reduce costs, Sylvania experience paid off. Sylvania Engineers demonstrated they could weld a tiny gold dot at the contact point economically while maintaining close tolerance on the critical dimensions of the formed contact. High-speed, high-volume techniques enable Sylvania to meet critical deflection and sheer tests. Sylvania maintains a metal stamping facility which includes multi-slide machines, vertical presses, and specially developed machines to help solve your special problems.



CUSTOM ASSEMBLY by Sylvania of the block and the parade of contacts is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or all customer components, or both—*at lower cost than is possible in the customer's own facilities.*

Result to IBM? Many, many thousands of completed top-quality assemblies per month, and to tolerances specified for automatic wire wrap.

QC SERVICE MEANS QUALITY CONTROL!

At Sylvania, a tough-minded, hard-to-please quality control department has full authority for assuring the parts Sylvania produces meet your most stringent specifications. Example of this thoroughness: for the IBM connector block, Sylvania used *100% inspection!*

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

For more information, turn to Reader Service card, circle No. 410

For high strength without excessive weight, the designer of this heavy truck chose Tenzaloy for the front engine supporting frame.

Why TENZALOY is the most widely used high-strength aluminum casting alloy

Among high-strength, self-aging aluminum casting alloys, Tenzaloy has won greatest acceptance and widest use by designers because of its unique all-round combination of properties. Outstanding among these special qualities are:

- High yield and tensile strength, combined with adequate ductility
- Exceptional machinability
- Remarkable dimensional stability
- High impact, shock resistance

When Tenzaloy is specified, one big problem is eliminated: heat treatment. Without any artificial thermal treatment, Tenzaloy castings will precipitation-harden at room temperature to give properties normally obtainable only by the expensive solution treating, quenching, and artificial aging of the heat-treatable alloys.

Here are typical properties for Federated Tenzaloy:

Tensile strength	35,000 psi
Yield strength	25,000 psi
Elongation (in 2 in.)	4-5%
Brinell hardness No.	74
Impact strength (Charpy in ft.-lbs.):	
Notched	3
Un-notched	14
Electrical conductivity	35%

Tenzaloy also is corrosion resistant, has superior ductility, and is easily anodized, dyed and polished to brilliant decorative finishes. Castability is excellent in green sand, plaster, investment, shell, oil-bonded sand and precision molds of all kinds. No special techniques are required for handling Tenzaloy in the foundry. Since Tenzaloy has mechanical properties equivalent to such common heat-treated alloys as 195T6, 355T6, 356T6 and 319T6, it can be substituted in applications where any of these heat-treated alloys are presently used.

It is particularly suited to high-strength designs where load carrying capacity and impact strength are essential. For example: frames, brackets, levers, bases, housings, missile ground handling equipment, jet aircraft turntables, explosion-proof enclosures, heavy-duty wheel hubs and cable drums, to name a representative few.

Tenzaloy can widen your design possibilities, increase production efficiency, improve your products, reduce costs. Get complete facts on its physical and mechanical properties by writing for Bulletin No. 103 R5 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

TENZALOY

FEDERATED METALS DIVISION **ASARCO**

American Smelting and Refining Company
120 Broadway, New York 5, N. Y.

For more information, turn to Reader Service card, circle No. 352

For more information, circle No. 342

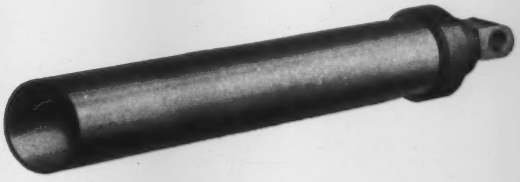
NO CEREMONY

In today's hustling, bustling construction business there's no time to stand on ceremony . . . no point in risking costly equipment failure.

To short-circuit mechanical downtime, leading construction equipment producers specify Ohio Tubing for power cylinders and fluid lines, mechanical and structural members. This gives equipment the heft and brawn to shrug off brutal, grinding punishment . . . gives equipment users a high degree of protection against disastrous delays.

You can strengthen your product — and its mechanical reputation — by specifying Ohio *Custom Made* Tubing. The name Ohio is the hallmark of the highest quality in tubing, both seamless and welded. And we're now able to deliver a broader range of welded tubing sizes, wall thicknesses and grades than ever before.

Let's not stand on ceremony. We want your tubing business — seamless to 7" OD, *welded up to 7½" OD.* For a fast start, contact your nearest Ohio representative, or send part drawings to the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry In America.*



Ohio Seamless offers the broadest parallel range of both welded and seamless quality steel tubing in the industry.

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Representatives in principal cities. Check leading directories: THOMAS', MacRAE'S, CONOVER-MAST, SWEET'S, FRASER'S.

A-3305A

Find out today how REVERE TUBE-IN-STRIP can help you save money . . . improve product quality

Shown on these pages are three of the many, many ways Revere Tube-In-Strip is used. Such money-saving performances are made possible by the fact that Revere Tube-In-Strip is a solid piece of flat sheet or strip metal with built-in passages that may be inflated, by pressure, into tubes. Thus the tubes become an integral part of the metal.

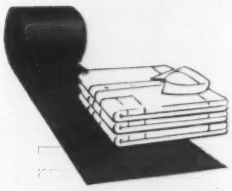
Expanding in the open, the tubes are round; by expanding into dies, the tubes can be rectangular, fluted, half-round, hexagonal, etc.

Revere Tube-In-Strip saves on first cost, and in fabrication. New and improved designs are made possible. The web between the tubes conducts heat faster. The vastly increased structural strength means you can use lighter gauges, saving in weight and price.

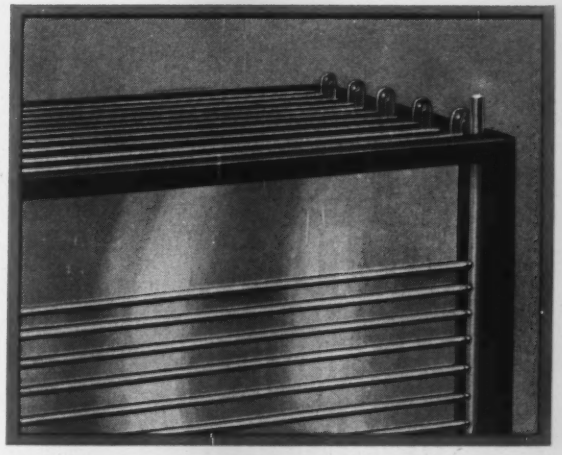
Revere Tube-In-Strip is available in Copper, Copper-base alloys, and Aluminum alloys. The Revere Technical Advisory Service and the Research and Development Department will gladly collaborate with you in taking full advantage of this marvelous new material.

REVERE
COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
Executive Offices: 230 Park Avenue, New York 17, N. Y.
Sales Offices in Principal Cities. Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford and Plymouth, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb.
Distributors Everywhere

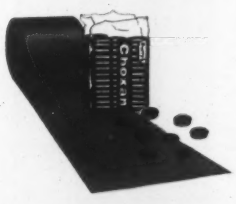
*SAVES $1,485.37 in 4-month period as Heat Reclaimer . . .



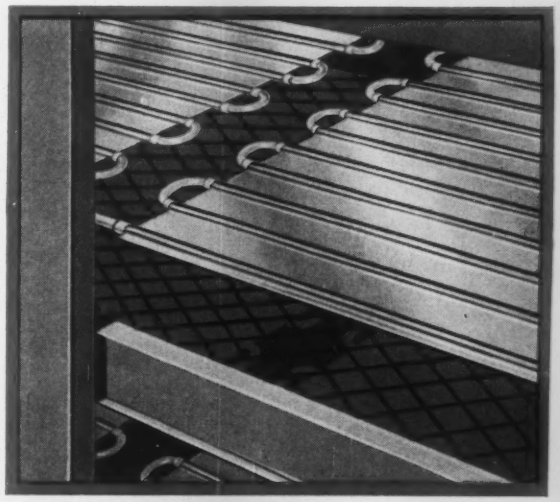
This heat reclaimer, made by KILLEBREW ENGINEERING CORPORATION, St. Louis, Mo., consists of a battery of 30 panels, with 3 panels of Revere Copper Tube-In-Strip, riveted together, measuring 48″ x 82″ overall. Water used for washing is heated as it flows through the tubes. The unit, installed in the 78-year-old industrial laundry operated by CHAS. TODD OVERALL CLEANING CO., saved, in a 4-month period, $1,485.37, with the laundry operating on a one-shift basis and at the desired water temperature. During that time, 200,000 more pounds of laundry were washed than in the previous 4 months at a $100.00 saving in steam cost. Prior to that time, due to a limit on the amount of steam that could be purchased, the laundry had to use a lower water temperature and operate on a two-shift basis.



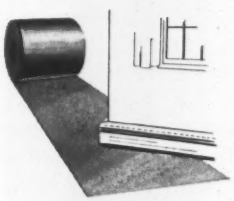
*SAVES UP TO 30% for biscuit maker, improves product quality . . .



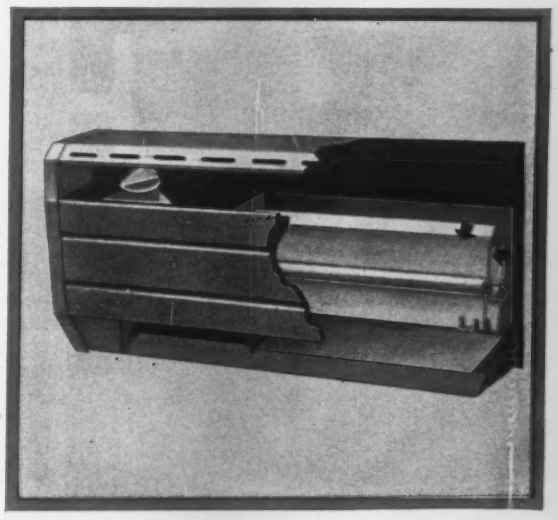
At the BURRY BISCUIT CORPORATION, Elizabeth, N. J. about 7,000,000 lbs. of product is turned out in 20 days, a large portion of which is chocolate coated and processed through the Reflectotherm system of reflective radiant cooling. This unit consists of a 108′-long, fully enclosed tunnel. On top and bottom of the tunnel are nine 8′ sections of Revere Copper Tube-In-Strip through which is pumped a cooling medium at 8 to 12 degrees F. This results in the chocolate, through radiation, being set properly within 4¼ to 5 minutes. Also included in this installation is a Reflectotherm drying unit, made of Revere Tube-In-Strip, by which 250 cubic feet of super-dry air per minute, at a temperature below zero, is forced between the plates. Burry Biscuit, one of the country's leading independent bakers, reports a tremendous improvement in product quality with an increase in production running as high as 30%.



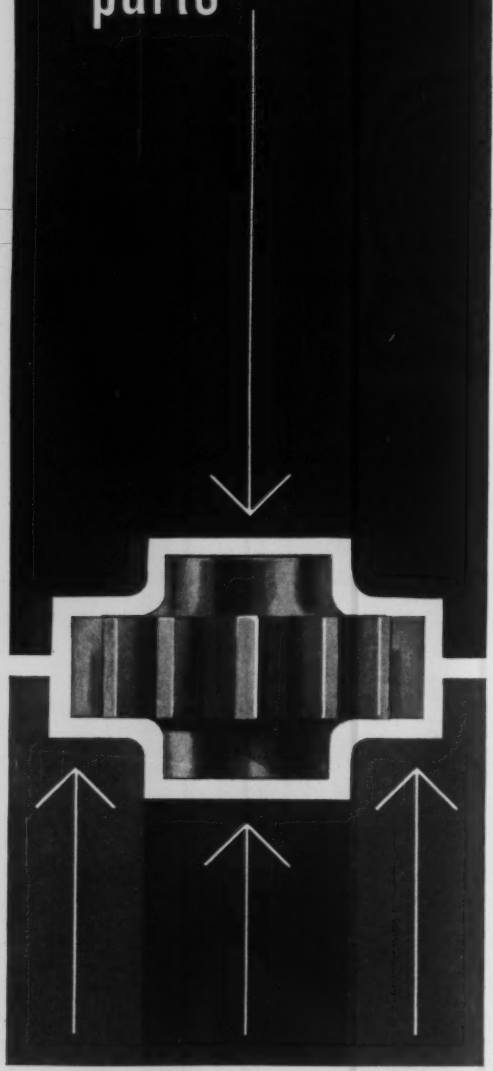
*SAVES MANUFACTURING COSTS increases efficiency of Electric Baseboard Heaters . . .



MEIER ELECTRIC, Indianapolis, Indiana, chose Revere Aluminum Tube-In-Strip for their line of electric baseboard heaters after numerous materials and designs were tested by their Engineering Department. The rigid design objectives were: (1)—Encase Heaters in a non-corrosive material, (2)—Use Tandem 500 plug-in case for 500, 750 and 1000 watt units while maintaining lower case temperatures at all wattages, thus eliminating duplication of dealers' stocks, (3)—Include inbuilt thermostats, junction boxes and thermal cutout in the unit to simplify construction, save space and cut manufacturing costs, (4)—Retain the quietness, lack of wall streaking and safe, low case temperatures originally available only in the 500 watt Tandem. All of these objectives were ultimately accomplished by using Revere Aluminum Tube-In-Strip to encase their heating element (see arrows).



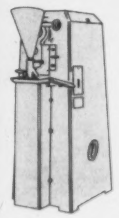
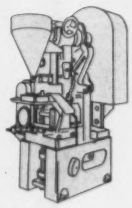
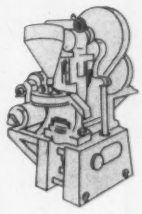
EXTRA MOTION for complex powder metal parts



Stokes answers the growing need for extra motions in the manufacture of more complex parts by adding three *new* machines to its extensive line of compacting presses. In each compacting press, the design of the secondary lower motion enables the operator to adjust timing, duration, and length of thrust independent of the mechanical timing of the pre-set main operating cycle of the press. The built-in secondary lower motions may be used as compacting punches or core-rods (stationary, movable, stripping, or ejection type).

These low and medium-pressure presses give you all the advantages you would expect to find in a Stokes press . . . accuracy, high production rates, ease of adjustment, and little maintenance . . . *plus extremely flexible lower motions.*

SINGLE-STATION MULTIPLE MOTION PRESSES

Model 572-1	Model 573-1	Model 574-1
4 TONS	12 TONS	20 TONS
		
4 TONS + 1 TON	12 TONS + 3 TONS	20 TONS + 5 TONS

For complete technical data on these single-station multiple motion presses, write for Data Sheet 126. Consult Stokes Engineering Advisory Service for complete technical assistance in designing parts, punches and dies, or complete production facilities.

STOKES

POWDER METAL PRESS DIVISION • **F. J. STOKES CORPORATION** • 5500 TABOR ROAD, PHILADELPHIA 20, PA.

For more information, turn to Reader Service card, circle No. 337

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Re-draw die uses 36 pieces of water-hardening tool steel

This large re-draw die shapes an intricate rear floor pan, made of sheet steel, for an American-made automobile. The die contains 36 pieces of Bethlehem carbon tool steel which serve as wear plates, inserts, keeper blocks, and insert plugs. The 17-ton die was produced in the shop of Modern Die & Tool Co., Utica, Mich.

The wear plates and inserts were hardened to Rockwell C 58-60; the keeper blocks and insert plugs to Rockwell C 50-52. The die maker liked the die for its easy machinability and ease of heat-treatment; the automotive manufacturer liked its resistance to wear and shock, and superior weldability when changes were required.

Due to their controlled hardenability, Bethlehem carbon water-hardening tool steels are ideal for applications calling for high shock-resistance. They are also resistant to wear, and have the toughness to withstand cold battering.

Your Bethlehem tool steel distributor can help you to find out how good a job Bethlehem carbon water-hardening tool steel can do. And he can give you good advice on the selection of other fine Bethlehem tool steels. Give him a call now!

BETHLEHEM TOOL STEEL ENGINEER SAYS:

"Touchy" Tools Should Be Ground On Edge of the Grinding Wheel

A choice of grinding methods is often available on many types of tools. They can be ground either on the side (face) of a grinding wheel in order to cover the whole area to be ground; or they can be ground on the edge (OD) of the wheel by traversing a number of parallel paths to cover the area selected for grinding.

Where the tools to be ground are exceptionally high in hardness, or if they are made of wear-resisting steels, or if there is a history of sensitivity to grinding cracks, edge-grinding is definitely best. The use of a grinding fluid for effective cooling is also essential.

By grinding on the edge of a grinding wheel, only a small area of the wheel is in contact with the tool at any moment. This permits more effective cooling action of the grinding fluid than when a large area of the wheel contacts the tool.

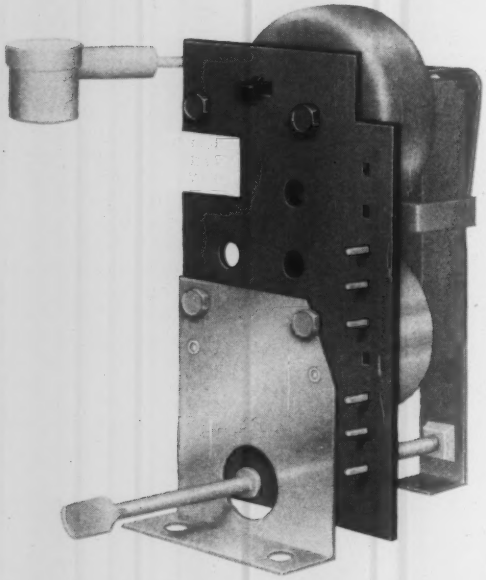
Cromo-High V (H-13)

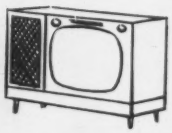
Ideal for Die Casters

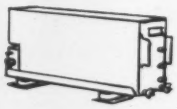
Die casters everywhere are getting fine results from Bethlehem Cromo-High V (H-13) tool steel. This 5 pct chrome-moly hot-work grade is furnished with 1 pct vanadium, and has all the features for good die-casting dies. Cromo-High V has good resistance to wash and erosion, and is plenty tough. It comes uniformly annealed for easy machinability. In addition, Cromo-High V has good center density and grain refinement, and resistance to heat-checking.

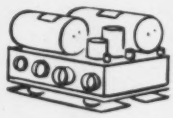
For more information, turn to Reader Service card, circle No. 363

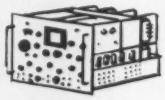
NEW SPAULDITE XXXP-770 PHENOLIC LAMINATE COMBINES *COLD PUNCHING* AND *FIRE RESISTANCE* . . . COSTS LESS THAN PAPER EPOXIES











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Shearing Quality	Cold
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Dissipation Factor 1 MC	
Condition A	.029
Condition D-24/23	.034
Dielectric Constant 1 MC	
Condition A	4.4
Condition D-24/23	4.6
Dielectric Strength Parallel to Plys KV	
Condition D-48/50	49
Rockwell Hardness M Scale	
Condition A	78
Flame Test D635 Inches Burned	
(in 2 ignitions after 28 days at 135°C)	5/8

COPPER CLAD XXXP-770

Surface Resistivity — ohms/cm sq.	
Condition C-96/35/9	1×10^{13}
Peel Strength as rec'd and after solder dip	
lbs./in. width	8.0
Solder Blister at 500°F Seconds	15.0

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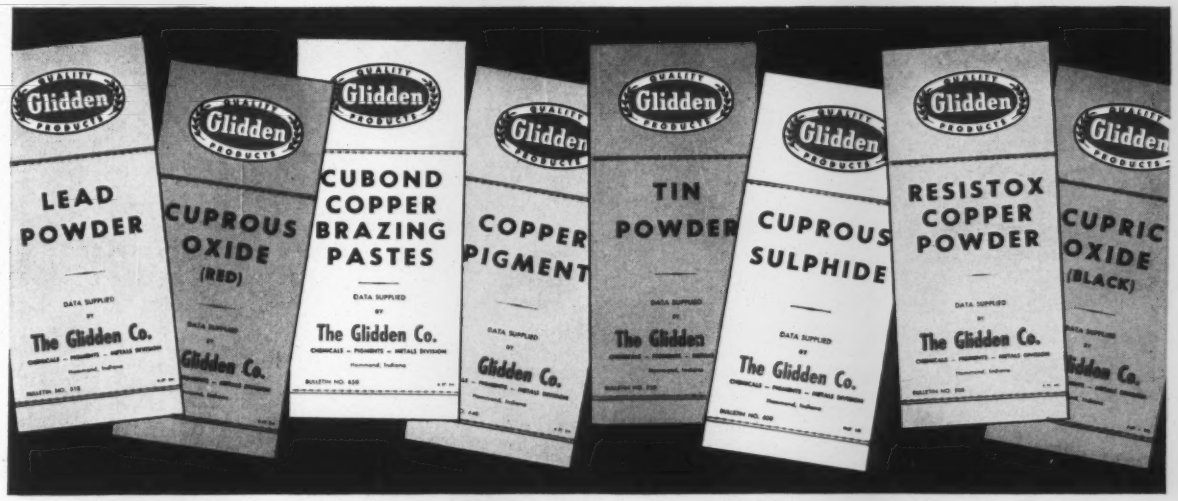

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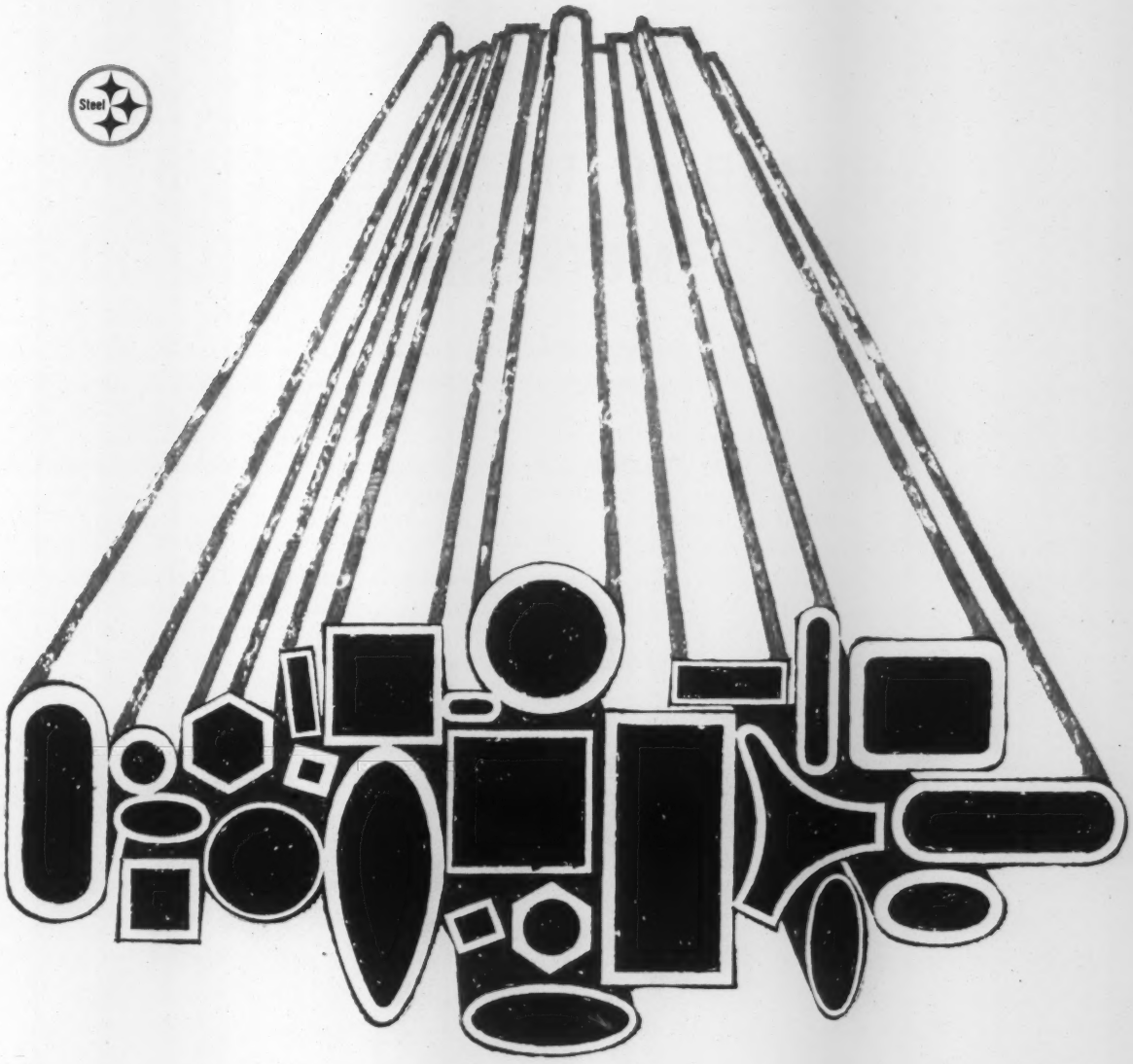

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Scheduled for fleet delivery in 1961, the all-weather Kaman HU2K "SEASPRITE" was developed to meet *high-performance* requirements of the U. S. Navy. Working closely with Kaman design engineers, Republic Steel is supplying light gage titanium and stainless steel for the HU2K.

Selected for its resistance to corrosion and abrasion, stainless is used in leading edges of the rotor blades. The titanium—Type RS140—is used in 1½″ x 18″ strips. Assembled in bundles of 88, these strips are machined into retention straps that are a vital component in the rotor system.

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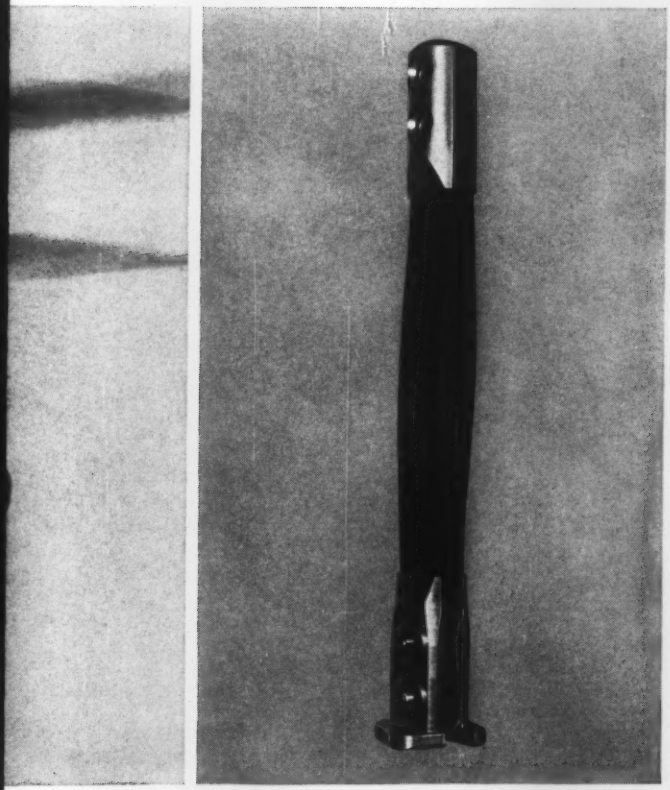
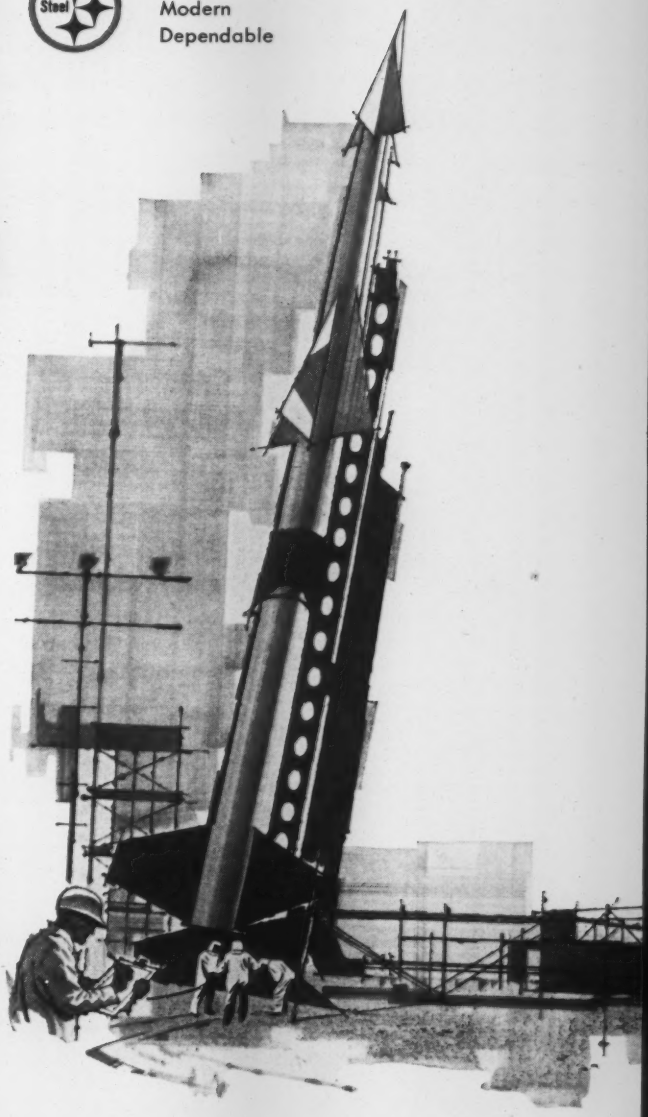


BUNDLED TITANIUM RETENTION STRAPS are designed to work through a torsion angle of ±13°. Each strap provides a minimum tensile strength of 155,000 psi. The HU2K "SEASPRITE" is manufactured by the Kaman Aircraft Corporation, Bloomfield, Connecticut.



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Result—when this soft drink dispenser is assembled the seams are practically unnoticeable. In addition, the selection of the proper plastic, combined with General American's skill in molding, provides a product with very good luster, high impact properties, excellent stain resistance—and a reasonable price tag.

If you have a part or product that could or should be made of plastics, consult General American. In plastics, *it pays to plan with General American.*

in this 6-piece soft drink dispenser

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ENGINEERING & DESIGN

...AT A GLANCE

Development of gallium arsenide diodes that act as variable capacitors is another breakthrough in microwave technology. The sensitive diodes, smaller than buckshot, amplify very weak signals up to a useful level, and are expected to help make possible very compact, long-lived microwave systems.

Source: Radio Corp. of America, 30 Rockefeller Plaza, New York 20.

Cladding steel rolls with polyvinyl chloride pipe is said to improve performance and increase durability of the conveyor rolls in papermaking machinery. A replaceable plastics sleeve, shrunk onto the roll, resists both acids and abrasion. The steel core construction results in less roll whipping than encountered with previously used brass rolls.

Source: A. M. Byers Co., Pittsburgh 22, Pa.

Two small copper slugs with equal masses are the electrodes in a needle-like, electrolytic cell designed to precisely balance miniaturized mechanical systems. Application of d.c. or rectified a.c. pulses is said to cause one electrode to lose metal to the other, practically atom by atom, thereby shifting the balance of the system. Amount of displacement is said to be accurately governed by the direction, duration and strength of the input current.

Source: Avcon, Box 3431, Grand Central Station, New York 17.

Large nonmagnetic coil and variometer frames for a very-low-frequency transmitter have been designed with wood-plastic laminates. The transmitter broadcasts underwater to submerged submarines. The laminated variometer structures are almost 22 ft high and are said to have an angular distortion less than 10 min while loaded with 2 tons of cable. Each coil frame, 34 ft high, supports 25,000 lb of cable with equal accuracy.

Source: Permali, Inc., Box 718, Mt. Pleasant, Pa.

Truck tank made of glass fiber reinforced polyester is used for hauling vinegar, alcohol and similar liquids. It is claimed to cost 15% less and offer a 20% maintenance saving over similar stainless steel equipment. The tank, a self-supporting compartmented tube mounted on a lightweight steel chassis, does not require bracing when loaded and is said to be leak-proof.

Source: Tank by Beetle Plastics Corp., Div. of Crompton & Knowles Corp., Fall River, Mass.

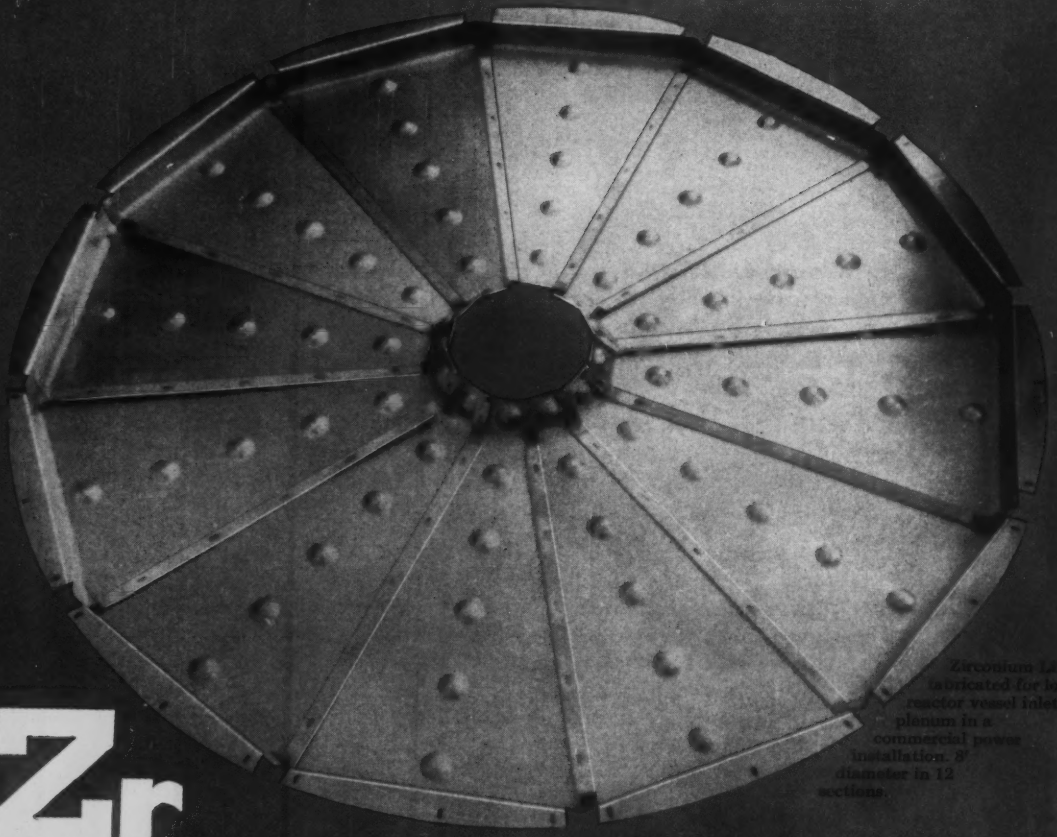
A piezoelectric spark source can replace magneto and condenser starter assemblies in small gasoline engines. Two small quartz plates are said to produce a 20,000-v charge (enough to activate a sparkplug) when subjected to ordinary hand pressure. The unit is being used on power lawn mowers and garden equipment.

Source: Cleveland Graphite Bronze Div., Clevite Corp., Cleveland, Ohio.

Life of chromium-plated parts running against bronze at high pressures and speeds can be extended by substituting lead-coated cast iron for the bronze and carburizing the chromium, according to recent Russian research.

Source: Review of the Soviet Technical Press, July 8, '60, Office of Technical Services, Washington 25, D. C.

CATCHES MOLTEN URANIUM



Zirconium Liner fabricated for lower reactor vessel inlet plenum in a commercial power installation. 8' diameter in 12 sections.

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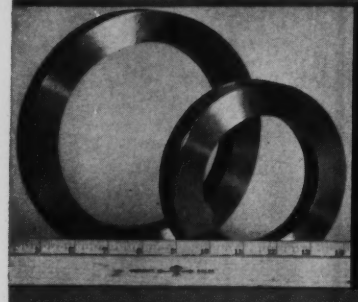
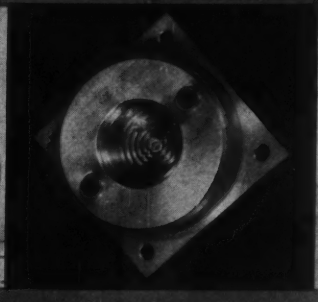


Scatter Rings Used in Radiation Research



Zirconium Metal Cathode

Valve Resists Severe Corrosion

Crucibles Cost Less To Use

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The Newer Insulating Gases

For electrical equipment operating at higher temperatures and voltages, dielectric gases better than air or nitrogen are needed. Electronegative gases may be the answer.

by Frank M. Clark, *Consulting Engineer*

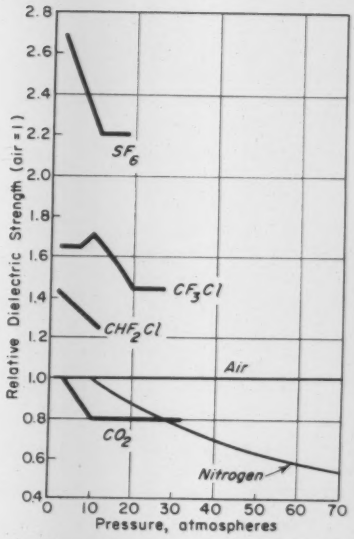
■ High dielectric strength and in some cases substantially improved cooling characteristics are the primary attributes obtainable in sulfur hexafluoride and the halogenated hydrocarbons. These two groups of gases—halides of sulfur and halides of carbon—are among the most important of the electronegative gases used as dielectrics.

Table 1 lists the relative dielectric strengths of these gases. Fig 1 compares dielectric strength vs pressure. Obviously, the high dielectric strength of these gases offers the engineer practical advantages over nitrogen and air. However, the dielectric peculiarities of gases under varying conditions of use (see box, p. 99) preclude the direct substitution of these newer materials without complete study of their unique behavior.

TABLE 1—DIELECTRIC STRENGTH OF ELECTRONEGATIVE GASES[a] (Average; Relative to Air)

Air	1.00		
Sulfur Hexafluoride (SF_6)	2.35		
Halogenated Hydrocarbons			
CCl_4	6.33	$CHClF_2$	1.40
$CHCl_3$	4.24	$CHCl_2F$	1.33
CCl_3F	3.50	CH_2ClF	1.03
CCl_2F_2	2.42	CF_4	1.01
$CClF_3$	1.43		

[a]In uniform d.c. field.



1—Comparison of relative dielectric strength: electronegative gases vs air and nitrogen (air = 1).

Sulfur hexafluoride:

High dielectric strength plus superior cooling ability

Physical properties of sulfur hexafluoride are shown in Table 2. In addition to substantial improvements in dielectric strength as compared with air or nitrogen, sulfur hexafluoride provides superior cooling characteristics. It is used in transformers, capacitors and electrical switches. It has also been suggested for use in waveguides.

Stability

Sulfur hexafluoride is highly stable chemically at atmospheric pressures and at temperatures to at least 212 F. At high temperatures it reacts rapidly with silicate glasses and with certain metals. But it is generally inert to commonly used electrical metals such as copper, steel and aluminum within the operating temperature range normally encountered. Specifically, it is stable within the Class A (up to 220 F) insulation range.

Arc degradation may produce toxic or corrosive products. The use of an alkaline "getter" material is desirable in order to remove the corrosive degradation products from the gas.

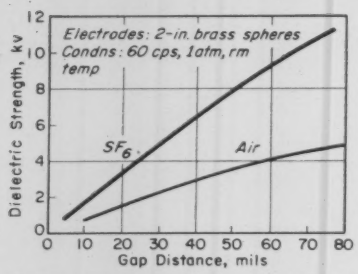
TABLE 2—TYPICAL PHYSICAL PROPERTIES OF SULFUR HEXAFLUORIDE (SF_6)

Molecular Weight	146.06
Melting Point, F	−58 to −68
Sublimation Temp, F	−80
Specific Heat (86 F), Btu/lb/F	0.143
Density	
Solid (−58 F), gm/ml	2.51
Liquid (77 F to −58 F), gm/ml	1.33-1.87
Gas (14.7 psi, 68 F), gm/ml	6.1-6.2
Relative (air = 1)	5.1
Critical Points	
Pressure, psia	540-605
Temperature, F	113-129
Density, gm/ml	0.755
Surface Tension (−58 F), dynes/cm	11.63
Coef of Ther Exp (−4 F), per °F	0.015
Ther Cond, Bu/hr/sq ft/F/ft	0.813
Viscosity (gats at 77 F), poise	1.61 x 10^{-4}
Vapor Pressure (68 F), psi	150
Refractive Index (32 F), D	1.000783

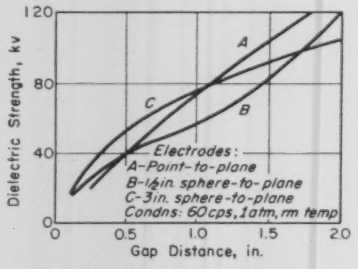
Cooling ability

Specific heat and thermal conductivity of sulfur hexafluoride are generally considered to be comparable with those of air or

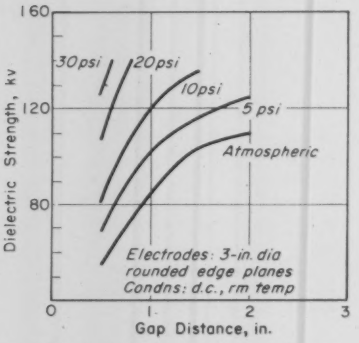
Effects of service variables on electrical properties of sulfur hexafluoride (SF_6)



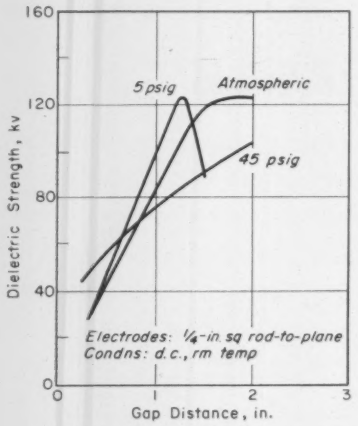
2—*Gap distance-strength relationship in a uniform electrical field. This pattern is common.*



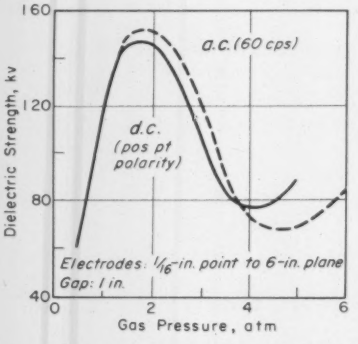
3—*Effect of three electrode shapes on dielectric strength of SF_6. Nonuniform electrical fields produce abnormal results.*



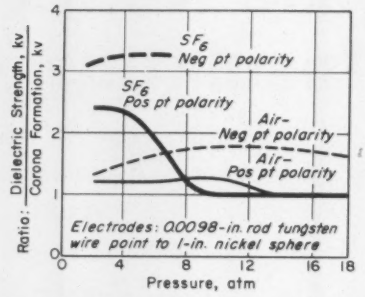
4—*Effect of pressure on gap distance-strength relation in SF_6. As expected, dielectric strength increases with pressure and with gap distance in a uniform electrical field.*



5—*Gap distance-strength relationship in a nonuniform electrical field as affected by pressure. Note that dielectric strength of the gas under 5 psig pressure actually decreases as gap distance increases beyond 1¼ in.*



6—*Gas pressure vs dielectric strength for d.c. and 60-cps a.c. voltage. Dielectric strength increases normally with pressure up to about 1 atm. Further increase in pressure produces a divergence from the straight line until a maximum strength is reached at about 2 atm. Increasing pressure beyond this point results in a drop in strength, the minimum occurring at about 5 atm.*


SF_6 Neg pt polarity
SF_6 Pos pt polarity
Air-Neg pt polarity
Air-Pos pt polarity
Electrodes: 0.0098-in. rod tungsten wire point to 1-in. nickel sphere
Ratio: Dielectric Strength, kv / Corona Formation, kv
Pressure, atm

7—*Breakdown voltage-to-corona voltage ratio vs pressure for SF_6 and air under both positive and negative point polarity.*

nitrogen. However, viscosity is only about 161 × 10^{-6} poise (vs 178 and 172 × 10^{-6} poise for nitrogen and air, respectively), providing a considerable improvement in convective cooling ability.

For example, in a layer-wound coil sulfur hexafluoride provided heat transfer 1.6 times that of air. Also, in testing a transformer, a mixture of 67% sulfur hexafluoride and 33% air was compared with 100% air. The mixture reduced hot spot temperature to 300 F, compared with 364 F for 100% air. The mixture also produced a corresponding reduction in the average temperature of the high voltage transformer winding.

Dielectric strength

Because of the effect of operating and design variables on dielectric strength, the comparative value of 2.35 shown in Table 1 for sulfur hexafluoride is only an average. An exact knowledge of breakdown strength under well-defined conditions is necessary for proper engineering use of the gas. Effects of some variables such as electrode configuration, gap distance and pressure are shown in Fig 2 through 6.

Under d.c. voltage, polarity of the electrodes also affects breakdown strength. For gap distances under ½ in., the effect may be negligible; for distances greater than ½ in. breakdown value may be greater by about 100% when the electrode responsible for the nonuniformity of the field is negative, as compared to similar breakdown values where the causative electrode is positive.

Effects of corona

Corona formation in sulfur hexafluoride assumes major importance in nonuniform electrical fields. In uniform fields breakdown of the gas is preceded only by a weak current flow, measured usually in microamperes.

Corona may start well below breakdown—Corona formation in sulfur hexafluoride is particularly objectionable because "getter" materials should be used to prevent

corrosion due to degradation. The voltage at which corona begins is critical because in this gas the spread between corona initiation voltage and breakdown voltage is frequently much wider than in air or nitrogen. Consequently, rather than ratios correlating the breakdown voltages of the gas and air, it is often advisable to consider the corresponding ratios relating corona initiation voltages for the two gases as having the greater significance.

In nonuniform electrical fields, the variability in corona initiation voltage and breakdown voltage makes it difficult if not impossible to establish any fixed values for these voltages, or for relations between them. Fig 7 illustrates this difficulty, showing also the effects of electrode polarity.

Note that when the point electrode is negative, the dielectric breakdown value for sulfur hexafluoride is roughly three times its corona formation voltage. Under such conditions corona formation voltage is probably the more practical design consideration.

Note also that when the point electrode is positive and pressure is low (on the order of 2 atm), breakdown voltage may be more than twice the corona formation voltage. Here again the corona voltage value may be the more significant design value. However, as gas pressure increases under the same testing conditions, the difference in voltages at breakdown and corona formation decrease until, at sufficiently high pressures (above about 10 atm under these test conditions), breakdown occurs simultaneously with formation of corona.

Reducing voltage spread may require lower breakdown value—In developing a safety factor to use with sulfur hexafluoride, remember that the breakdown ratio is invariably lower when the electrode that promotes the nonuniformity of the electrical field is of positive polarity. But this is the polarity under which the breakdown-corona ratio is at its highest (i.e., the worst condition from the design standpoint) under gas pressures up to about 6 atm—a range that encompasses the pressures most commonly used.

Impulse voltage breakdown

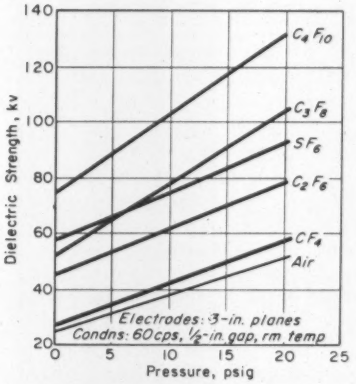
Breakdown of sulfur hexafluoride gas under impulse voltages is affected by the same factors that affect a.c. (60 cps) and d.c. breakdown, i.e., temperature, pressure, gap distance, field uniformity, and polarity of the impulse voltage, as well as the wave form. These factors have not been satisfactorily evaluated to the degree that reliable values can be given. A thorough study of the conditions should be made.

Halogenated hydrocarbons:

commercial refrigerants offer high dielectric strengths

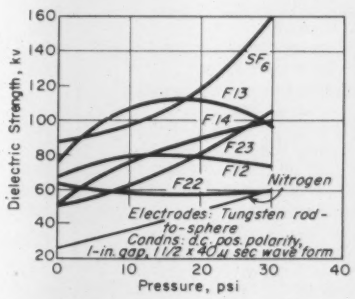
The most important of the halogenated hydrocarbon gases for dielectric use are the fluorinated and chloro-fluoro derivatives of the lower molecular weight alkyl hydrocarbons, e.g., the proprietary Freons and Genetrons. Their primary attribute is high dielectric strength.

Use of these gases as electrical insulators is relatively new.

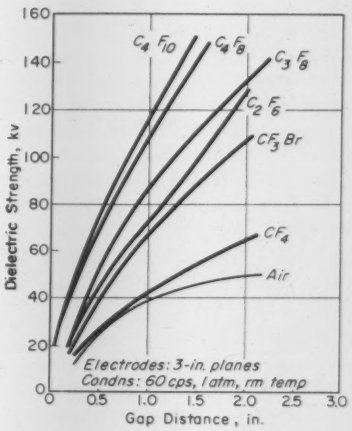


8—*Pressure-dielectric strength relationship vs that of nitrogen in a nonuniform electrical field.*

Effect of service variables on electrical properties of halogenated hydrocarbons



9—*Impulse dielectric strength-pressure relationship vs that of nitrogen in a nonuniform electrical field.*



10—*Gap distance vs dielectric strength in a uniform electrical field.*

Table 3 lists physical properties of some of the better known proprietary gases of this type as furnished by one supplier.

Stability

Fluorohydrocarbon gases are generally considered to be chemically stable. However, even minor traces of chemical instability can affect long-term dielectric behaviour. In the fluorinated hydrocarbon gas molecule, the halogen always presents a potentially severe corrosive and dielectric degradation problem. In attempting to use such gases at temperatures above Class A (220 F) temperature, it is necessary to evaluate the specific gas—particularly when it is to be used with cellulosic insulating materials.

Dielectric properties of halogenated compounds are particularly sensitive to radiation. This is undoubtedly due in part to the electrical nature of the degradation products formed. Such products, in addition, are frequently toxic and chemically corrosive.

Dielectric strength

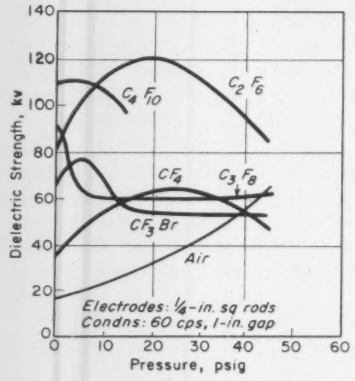
Although many data have been developed describing the dielectric strength of fluorocarbon gases under different service conditions, only typical data indicative of their usefulness are given here.

The different fluorocarbon gases have widely different dielectric strengths but all have breakdown strengths higher than that of air or nitrogen, as shown in Fig 8 and 9 for different pressures. Effects of other variables are shown in Fig 10 through 15. The same abnormal dielectric strength behavior in nonuniform electrical fields occurs with fluorocarbon gases as with other gases.

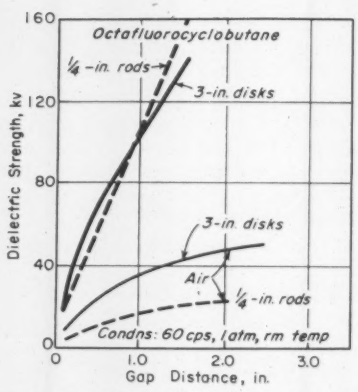
In commercial equipment gases are used under pressures up to 50 psig. As Fig 11 shows, at pressures of little more than 40 psig, only hexafluorethane (C_2F_6) has a dielectric strength superior to that of air.

Corona

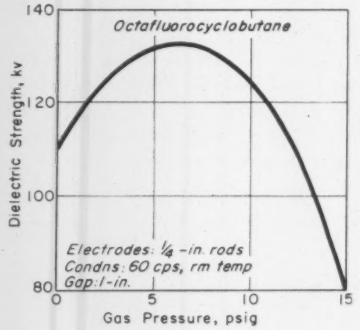
Fluorinated hydrocarbon gases present the same problems as sulfur hexafluoride in that corona formation before actual dielectric breakdown decomposes the gases,



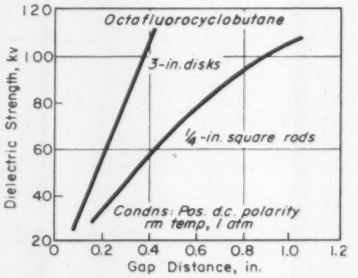
11—Pressure-dielectric strength relationship in a nonuniform electrical field compared with those of sulfur hexafluoride and nitrogen.



12—Gap distance-dielectric strength relationship in uniform and nonuniform fields for octafluorocyclobutane. Under atmospheric pressure, uniformity of the electrical field has a relatively minor effect on strength.



13—Pressure-dielectric strength relationship for octafluorocyclobutane in a nonuniform field. When pressure is increased above 7 psig, dielectric strength decreases markedly.

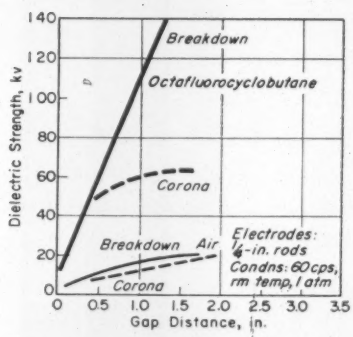


14—Gap distance-dielectric strength relationship for octafluorocyclobutane under impulse voltage of positive polarity in uniform and nonuniform fields.

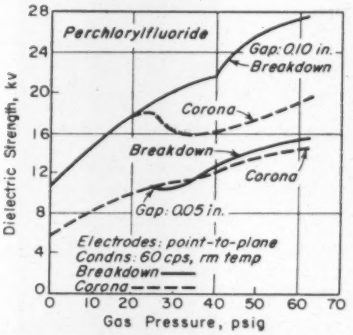
TABLE 3—TYPICAL PHYSICAL PROPERTIES OF SOME PROPRIETARY HALOGENATED HYDROCARBON GASES

Type[a] →	Freon 12	Freon 11	Freon 21	Freon 113	Freon 114	Freon 22
Boiling Point, F	−7	73	48	118	39	41
Freezing Point, F	−252	−168	−197	−31	−137	−256
Critical Points						
Pressure, psi	582	635	750	495	550	716
Temperature, F	234	388	667	417	293	205
Density, gm/cu cm	0.558	0.554	0.522	0.576	0.582	0.525
Specific Heat of Vapor (constant pressure), Btu/lb/°F	0.144	0.142	0.149	0.163	0.132	0.152
Toxicity by Volume, %	>20	>10	>10	>13	—	—
Thermal Conductivity/Btu, hr/sq ft/°F/ft						
Liquid	0.0492	0.0609	0.0697	0.0521	0.0447	0.0595
Vapor (1 atm)	0.005	0.0048	0.0057	0.0045	0.0065	0.0068
Viscosity (liquid, 86 F), cp	0.251	0.405	0.330	0.619	0.356	0.229
Surface Tension (77 F), dynes/cm	9	19	19	19	13	9
Solubility in Water, gm/100 gm						
86 F	0.012	0.013	0.160	0.013	0.011	0.15
32 F	0.002	0.003	0.055	0.003	0.002	0.060
Density (vapor, STP), 10^{-4} gm/cu cm	49.6	61.5	—	83.5	76.5	35.8

[a]Freon is registered trade name of E. I. du Pont de Nemours & Co., Inc.



15—*Corona-breakdown ratios for a halogenated hydrocarbon gas vs air at different gap distances.*



16—*Corona and breakdown values for a halogenated hydrocarbon gas as functions of pressure at two different gap distances.*

producing compounds that endanger both the dielectric and structural integrity of the electrical device. Again the use of "getter" materials is highly desirable to remove degradation products from the insulation system to prevent corrosion.

The problem is to design the equipment to provide the narrowest voltage difference between actual breakdown voltage and the voltage at which corona is formed. Fig 15 shows the effect of gap distance on the corona-breakdown ratio for octafluorocyclobutane compared with that for air. The advantage in using small gap distances is obvious. With a ¼-in. gap, breakdown and corona formation values for the fluoride gas are 4.5 times those of air. With a 1-in. gap, if corona formation voltage is the determining factor, the fluoride gas can only be designed to take an electrical stress of 3.7 times that of the air breakdown. If the design can be adjusted so that corona formation voltage is increased to equal the breakdown value, the fluorinated gas can be electrically stressed to voltages 5.9 times that of air.

Fig 16 shows the corona and breakdown voltage-pressure relationship for perchlorylfluoride gas in a nonuniform field. At pressures below about 20 psig, breakdown occurs simultaneously with corona formation. At high pressures, corona formation precedes breakdown.

What to Look For in Dielectric Gases

A pure gas free from all effects of incident radiation approaches the condition of a perfect insulator. Unfortunately, under normal conditions no gas is that pure. It is contaminated by the effects of radiation which result in the formation of charged particles, producing a degree of conduction.

Although all gases can be classified as dielectrics when pure, problems of chemical stability, corrosion, dielectric strength and dielectric loss, plus the highly practical considerations of flammability and explosive hazards, drastically limit the gases from which the engineer may choose.

The most widely used gaseous dielectrics are air and nitrogen. They are noninflammable, nonexplosive, plentiful, and have good dielectric characteristics. Hydrocarbon gases, such as methane, ethane and butane, have good dielectric characteristics, but their flammability and explosive nature make them of little interest.

Carbon dioxide has found limited use in certain types of fixed plate capacitors, and as a preimpregnant for oil-filled high voltage apparatus, but it has no outstanding advantage in comparison with air or nitrogen.

The more recent electronegative gases discussed in this article are becoming prominent because they offer distinct benefits in terms of improved dielectric strengths and cooling characteristics.

Electrical properties

Unlike liquid dielectrics (see M/DE, Nov '59, p 99) gaseous dielectrics all have approximately the same dielectric constant—about 1 or slightly higher. But dielectric strength varies widely, depending on the gas and the conditions under which it is used.

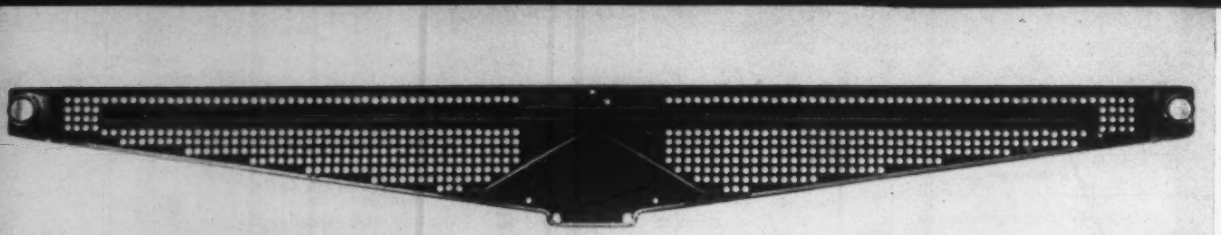
Unfortunately, dielectric strength cannot be stated definitively for a particular gas. The effects of such variables as pressure, gap distance, polarity, and uniformity of the electrical field have a critical effect on dielectric strength. In general, in a *uniform* electrical field, dielectric strength increases with increasing pressures, and gap distance. But in *nonuniform* electrical fields these relationships differ; also electrode polarity under d.c. voltage may affect dielectric strength.

The magnitude of the difference between the voltage at which corona formation begins and voltage at breakdown can be critical. Corona can cause severe chemical degradation in the gas, resulting in loss of dielectric characteristics and possibly production of corrosive or toxic products. Consequently, in many cases, maximum voltage for a particular piece of equipment should be that at which corona formation starts, rather than breakdown voltage.

Cooling characteristics

Gases can cool by 1) absorbing heat, as measured by specific heat, 2) conducting heat away from heat sources, as measured by thermal conductivity, or 3) convection, or physically carrying the heat away from the heat source, as measured by viscosity. In most apparatus, the gas's convective ability is of the greatest engineering importance.

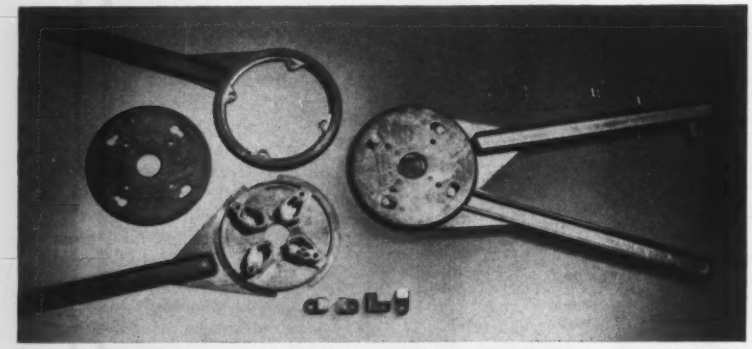
Full references for data are available from the author. Mr. Clark was also author of "Synthetic Fluid Dielectrics," M/DE, Nov '59, p 99.



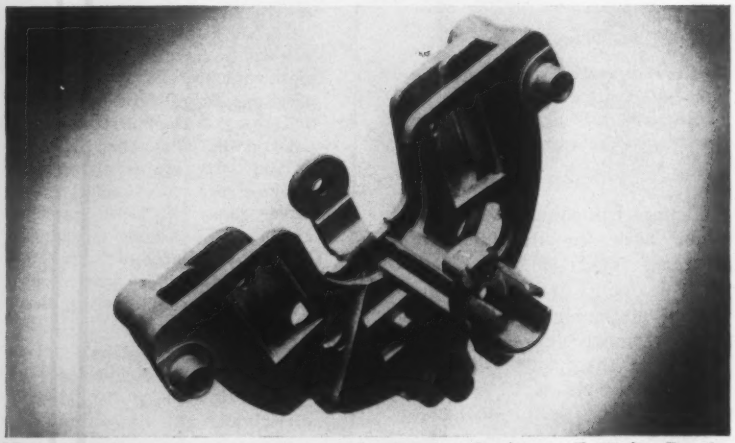
Winner: vacuum chamber plate *for a digital computer tape handler. It has 515 cored holes and is 95% cheaper than a machined plate. Designer: V. O. Anderson, A & A Die Casting Co.*

Prize Winning Zinc Die Castings

These zinc die castings are some of the winners in New Jersey Zinc Co.'s recent design contest. Emphasis was placed on designs exploiting the special properties of the material and process and on those achieving exceptional dimensional accuracy. The winner and five of the nine entries receiving Awards of Merit are shown here.

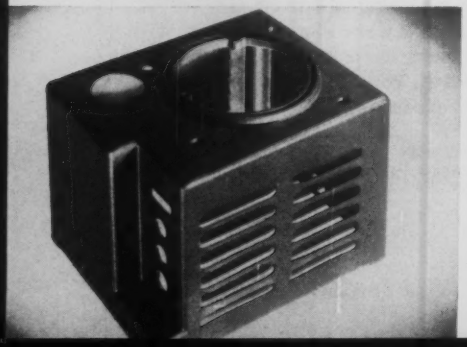


Ferrule clincher *for plastics tubing. Designer: T. N. Davis, Twin City Die Casting Co.*

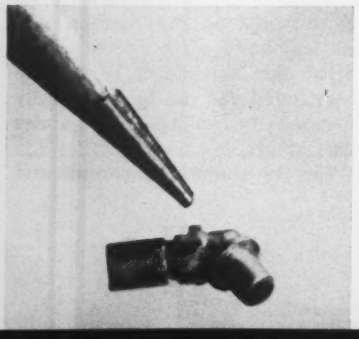


Mounting frame *for an ammeter and voltmeter. Designer: F. Wells, Peasley Products, Inc.*

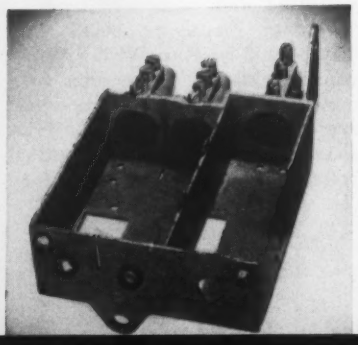
Blower housing *for an air-conditioned helmet. Designer: P. E. Berndt, Westland Die Casting, Inc.*



Miniature tube coupling *for a hearing aid. Designer: G. A. Meyer, Dollin Corp.*



Television tuner housing. *Designer: T. F. Groden, Serv-All Die & Tool Co.*



Five Ways to Control High Heat Flux

Keeping Temperatures Down — 1

Conduction / Convection / Radiation / State Change / Electromagnetic Energy Change

by Harry A. King, *Technical Director, Western Backing Corp.*

Fast-breaking developments in high speed aircraft, missiles and space vehicles have accelerated the need for materials and techniques capable of accommodating ultra-high heat fluxes. The older class of insulation materials alone cannot do the job. Today engineers find that they must use a combination of materials that form a thermal accommodation system. Furthermore, these new insulation systems must perform not only a thermal function, but also structural functions—and at the same time save weight and space.

The two-part series that begins with this article is an up-to-date survey of the ways you can keep high temperatures under control in both present and future applications. The articles have been designed to complement each other. In this first article, Mr. King presents a broad picture of the technique and methods whereby high heat fluxes can be controlled. In the second article next month, John Collins and Sidney Speil, of Johns-Manville Corp., will follow up with a detailed analysis of how these thermal control techniques can be implemented by three important groups of materials and materials systems: ablation, heat sink and radiation.

Although emphasis will be placed on aerospace applications, it is obvious that many of the techniques and materials systems can, with a little imagination, be adapted for high temperature industrial applications as well.

TABLE 1—A SUMMARY OF HEAT PROTECTION TECHNIQUES

Technique	Variation	Form of Heat Protection
CONDUCTION	Heat sink	Heat absorbed
	Regenerative or fluid cooling	Heat absorbed and conducted away
CONVECTION	Transpiration	Heat absorbed and prevented from entering
	Film cooling	Heat absorbed and prevented from entering
RADIATION	Radiation	Heat absorbed and re-radiated
	Reflection	Heat prevented from entering
	Insulation	Heat prevented from entering and re-radiated
STATE CHANGE (ABLATION)	Chemical	Heat absorbed and carried away
	Physical	Heat absorbed and carried away
ELECTROMAGNETIC ENERGY CHANGE	Magnetohydrodynamic (MHD)	Heat prevented from entering
	Thermoelectric	Heat transformed into another form of energy

Conduction

The technique of conduction relies on the ability of certain materials to absorb and conduct heat away from a surface. The technique is well-known and has been used for hundreds of years without difficulty. However, with the advent of aerospace applications where heat fluxes can exceed 1000 Btu/sq ft/sec, the control of heat by conduction has posed some tough problems.

Conduction can be accomplished in two ways: by heat sink materials and systems, and by fluid or regenerative cooling (see Table 1).

Heat sink systems

A heat sink utilizes a solid material to conduct heat away from critical areas. Such systems will be covered in detail in next

month's article on materials systems. However, it is well to note at this point that a heat sink is a "low temperature" system that operates below the melting point of the absorbent material. It works effectively only if the heat flux is no greater than can be accommodated by conduction. Since it is desirable to absorb as much heat per unit weight as possible, a successful heat sink is based on a material that has: 1) high heat capacity or specific heat, 2) high thermal conductivity, and 3) high melting or sublimation temperature.

Fluid or regenerative cooling

Fluid or regenerative cooling depends on the ability of a fluid to absorb and conduct heat away from a surface. As long as there is enough fluid flowing in the cooling channels adjacent to the surface, and thermal conductivity is sufficient to prevent the wall from melting, then the system will behave satisfactorily over a wide range of temperature and heat flux *independent* of the materials used in either the tubes or the cooling fluid.

Materials and design—The main problem in designing a fluid-cooled system is to determine how much heat must be extracted from the exposed wall to keep its temperature below the melting point. The velocity of the coolant for a given wall thickness must also be determined; it is desirable to obtain the required heat transfer with as low a velocity as possible in order to minimize the pressure drop due to velocity.

Analysis of cooling requirements frequently calls for a wall so thin that it is structurally unstable. In such a case it may be necessary to: 1) reinforce the inner wall of the cooling channel by tying it to the outer wall; 2) use tubes instead of channels composed of the inner and outer walls; or 3) use a thicker inner wall and employ film cooling (discussed later) in critical areas.

Commonly available materials such as stainless steel or aluminum are usually quite satisfactory for cooling channels or tubes. Sometimes, however, other factors such as erosion or oxidation may dictate the use of special materials. The coolant material should generally be a liquid which is both inexpensive and readily available. Usually it need have no special properties other than that it must not corrode the tubes or channels during the heat absorption process.

Concept of boiling heat transfer is promising—Boiling heat transfer is a promising concept which has been used to transfer heat in nuclear reactors and experimental automobile engines.

In such a system, heat transfer takes place by the usual convection process as the surface temperature is raised above that of the liquid. However, as the liquid nears its saturation temperature bubbles will form and accumulate. These bubbles produce a marked increase in heat transfer coefficient, so that a small increase in temperature will cause a very large increase in heat transfer rate.

A maximum heat transfer rate is reached just before the bubbles become so numerous that they coalesce periodically, forming an unstable and intermittent vapor blanket over the surface. Any additional increase in temperature only leads to more vapor formation and decrease in the heat transfer coefficient (see Fig 1). Eventually, a rather stable vapor film forms over the surface and at this point any further increase in surface temperature will again lead to an increase in heat transfer rate.

The region from the first formation of vapor bubbles to the point of maximum heat transfer rate is known as the nucleate boiling region. This is an optimum design area. The region in which the heat transfer rate decreases with surface temperature is called the partial film boiling region, and the region beyond has been named the stable film boiling region. The existence of a maximum heat transfer rate and the transition from nucleate boiling to film boiling becomes less pronounced as the pressure of the fluid approaches the critical pressure of the fluid (*Sabersky*).

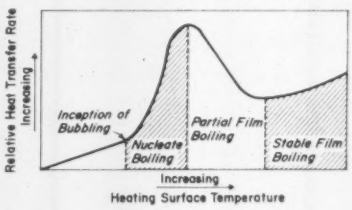
Convection

The technique of cooling by convection can be approached in two different ways: transpiration cooling and film cooling.

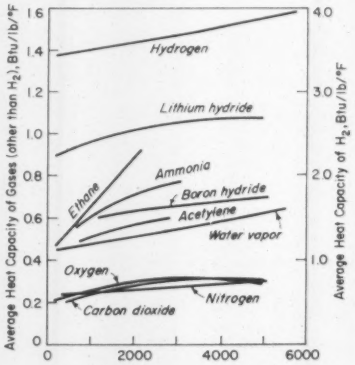
Transpiration cooling

Transpiration, or mass-transfer, cooling is the cooling of a surface by the addition of matter into the boundary layer at or near the surface. A porous metal or ceramic material is generally used as a skeleton through which the coolant is forced or "transpired." The coolant forms a protective blanket on the hot side which controls heat input by absorbing heat, by altering the flow pattern, and by thickening the boundary layer.

If the coolant fluid is the same as the mainstream fluid then the method is known as transpiration



1—How heat transfer rate varies with temperature.



2—Average heat capacity of various gases.

cooling. If the coolant and mainstream fluids are dissimilar the method is usually called mass-transfer cooling, although the term transpiration cooling is commonly used to denote both methods.

Liquid cooling—Although preliminary investigations might show that liquids would be excellent for transpiration cooling, results to date have not been encouraging. Invariably the liquid starts boiling locally at a hot spot in the porous section. The vapor thus formed drastically reduces the cooling value of the fluid at the hot spot (as described under boiling heat transfer) and the hot spot generally spreads quickly over the entire porous surface until an entire section is destroyed. In addition, the higher surface tension of a liquid (as compared to a gas) causes a substantially higher pressure drop across the porous wall. This makes it difficult to get enough coolant through the wall to obtain adequate cooling, especially under high heat flux conditions.

Because of the above reasons, gaseous coolants appear to be the most effective for transpiration cooling. Liquid transpiration cooling is generally used only: 1) to protect surfaces exposed to low heat fluxes; 2) where the liquid is considerably less expensive than the gas; or 3) where the weight of the pressurizing equipment is not important.

Gas cooling—The specific heat of several gaseous materials is shown in Fig 2 to indicate their usefulness as coolants. Obviously, a high heat capacity indicates a greater heat absorption potential per unit weight.

Generally speaking, coolants that react with the wall material at high temperatures are not desirable. Materials that might decompose and leave a residue in the transpiration pores are likewise not acceptable. Other factors such as cost and availability also have to be considered.

The porous wall—The wall of a transpiration cooled structure can be made of practically any material with uniform pore distribution. Materials such as sintered stainless steel, copper, nickel, molybdenum, graphite, carbon, ceramics, and wound and sintered metal fibers are all satisfactory provided that they do not react with the coolant or the atmosphere they contact. In general materials with high thermal conductivity, heat resistance, corrosion resistance and specific area are desired.

The metal fiber materials mentioned above are especially interesting and seem to have good potential because of their uniformity and strength. These materials are made from metal wire which is wound into a sheet of the desired porosity and then sintered (see "Fiber Metallurgy," M/DE, Dec '59, p 104). The resulting product is generally stronger than powdered metal. In addition, it is relatively easy to produce various shapes and, by using different winding patterns, to obtain variations in porosity and other special properties.

Film cooling

Film cooling differs from transpiration cooling in that the coolant is injected through individual holes spaced relatively far apart. It has the advantage of not requiring special porous materials; however, the wider spacing of the holes makes the protective film less effective than that produced from a porous unit.

Although gases are generally better for transpiration cooling, liquids such as water are usually best for film cooling. Liquid coolants are especially advantageous because of the heat absorption which derives from their latent heat of vaporization. One of the best-known applications of film cooling was in the thrust chamber of the V-2 missile where several sets of film cooling holes were provided to protect critical areas.

Two primary problems must be considered when designing a film cooling system: 1) the coolant must be injected so that it attaches to the surface to form a film; and 2) the area that can be cooled from a single injection station must be carefully determined.

Extensive experiments conducted on these two problems show that, in general, it is desirable to cool in such a way that a stable film is maintained to prevent fluid particles from being torn away and carried into the main stream. This means that only a relatively small injection area can be covered from each injection point, and many injection points may be required to protect large surface areas.

Radiation

The technique of radiation relies on the ability of a body to re-radiate heat back into its origin as fast as it is received. Probably the most important ways this can be accomplished is through the use of an insulation radiation system. An insulation system controls heat by a combination of: 1) direct reflection, and 2) absorption and re-radiation of heat back into its source. A complete survey of the state of the art of radiation insulation systems will be given in next month's article.

Radiation can also be accomplished by using a surface alone to control heat. If we use a bright, highly reflective surface, any heat applied to the surface will tend to be reflected back to the source with an absorption rate as low as 1 to 2%. Such a surface is the most satisfactory for short time, severe exposure conditions. The heat that is absorbed by the surface is not readily lost, and the surface will eventually become hot.

On the other hand, if the surface is a dull black it will absorb heat and act as an excellent radiator so that absorbed heat is readily returned. Such a surface is the most stable and efficient finish to use for long heating periods.

The absorption and re-radiation of heat back into space is an attractive cooling method for longer re-entry periods. For a perfectly emitting surface, a temperature of about 2000 F is required to dissipate the average heat flux

under typical re-entry conditions. This is the so-called "equilibrium temperature" — the temperature that a thin, perfectly insulated black surface would reach and maintain during re-entry.

The concept of using a thin, high-temperature radiating skin —supported by a structural insulation—for a re-entry body is tempting. But it must be approached with caution. Unlike the heat sink technique where the rate of heating is relatively unimportant, the success of a thin radiating skin is highly dependent on the maximum heat rate encountered. Thus, a momentary high heating rate could result in melting of the skin because of its thinness.

The following table shows the equilibrium temperatures of various coatings and surfaces on a spherical body in orbit around the earth:

Coating	Equilib Temp, F
Flat Black Paint	43
Glossy White Paint	—160
2024 Aluminum	
Plain	435
Anodized	60
Lacquered	35

Source: Materials Laboratory, Wright Air Development Center.

In actual practice, gold and platinum are used for reflective coating surfaces to prevent initial heat absorption. They are used because their excellent resistance to oxidation helps them maintain their reflective characteristics at high temperatures better than most solids.

State change

The state change technique uses the change in properties of a material to control heat. The change may be physical or chemical. Physical state change uses the absorption of heat that occurs during a physical change in the material. Similarly, chemical state change uses the absorption of heat that occurs when a material reacts with its environment. Alone or together, these changes are those we commonly associate with ablation.

An analysis of current ablation systems and materials will be presented in the next article. However, before going on to the materials *per se*, let us take a more general look at what is involved during state change and how it can be used to control heat.

Physical state change

Physical state change differs from chemical state change in that the heat absorption of the material is entirely due to physical effects such as melting, vaporizing, subliming or crystallizing. For example, Table 2 shows the variation in heat absorption properties of several potential materials as they are melted or vaporized, and Table 3 shows the melting and boiling temperatures of various materials and their associated efficiency of heat transfer.

Since much physical data are available it would seem that selection of the best material would be relatively easy. However, this is not the case. For example, if we take water in the form of ice, exposing it to a temperature of 5000 F, one of two things will happen: either the ice will explode from thermal shock, or the surface will melt and the water will flow or blow away. In either case the majority of the water does not remain in the heating area long enough to fully absorb heat.

Thus, the main problem in working with the technique of physical state change is to develop a satisfactory method for holding the material in place long enough to absorb its full complement of heat. Transpiration cooling would be a step in the right direction, but this technique still does not hold the material in place long enough. Another possible method is to embed the heat-absorptive material in a matrix of metal, ceramic or plastic that would transmit the heat to the material and prevent it from being carried away before it can melt, vaporize or sublime.

TABLE 2—HEAT ABSORPTION PROPERTIES OF MATERIALS

Material ↓	Heat of Vaporization, Btu/lb[a]		Heat of Fusion, Btu/lb[b]	
Graphite	21,450	(7580 F)	—	(6330 F)
Lithium	10,520	(2190 F)	287	(367 F)
Magnesium	4,640	(3450 F)	159	(1200 F)
Calcium	4,270	(2140 F)	—	(1490 F)
Aluminum	3,590	(3270 F)	170	(1220 F)
Copper	3,180	(4170 F)	88	(1980 F)
Water (for comparison)	973	(212 F)	144	(32 F)

[a]Pressure 1 atm. Temperature in parenthesis is vaporization temperature.
[b]Pressure 1 atm. Temperature in parenthesis is fusion temperature.

TABLE 3—LIQUEFACTION AND VAPORIZATION TEMPERATURES OF NINE MATERIALS

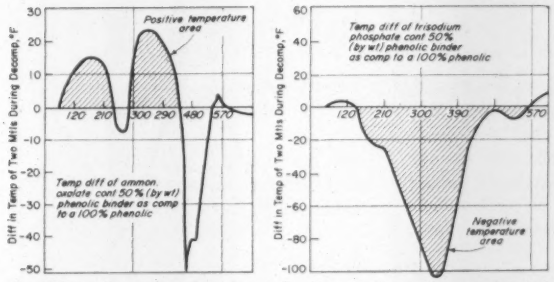
Material ↓	Melting Temp, F	Boiling Temp, F	Eff of Ht Trans, %
Hydrogen	—436	—423	0
Graphite	—	7800	99
Water	32	212	0
Beryllium	2462	5378	6
Beryllium Oxide	4586	7060	26
Magnesium Oxide	5072	6070	24
Helium	—458	—452	0
Silicon Dioxide	3110	4172	22
Copper	1980	4237	6

Source: *Gruntfest.*

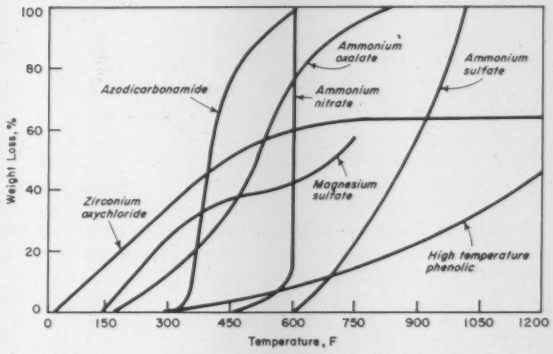
Chemical state change

The technique of chemical state change for thermal control utilizes materials that either react with their environment or decompose with an associated absorption of heat. One of the main problems with this technique is determining just how much a given material will absorb and how efficient it will be. Such properties as the heats of formation and decomposition are usually quite useless because a material does not suddenly decompose into its associated elements. Rather, it gradually breaks down into a series of intermediate components which, on further heating, break down into other components. This decomposition can be further complicated and altered by temperature, pressure and potential catalysts present. To further complicate the problem, a large part of the initial breakdown products are usually swept away in the boundary layer before they have a chance to absorb any further heat.

Differential thermal analysis— One of the ways we can measure a material's heat absorption poten-


Positive temperature area
Temp diff of ammon. oxalate cont 50% (by wt) phenolic binder as comp to a 100% phenolic
Diff in Temp of Two Mtls During Decomp, °F
Temp diff of trisodium phosphate cont 50% (by wt) phenolic binder as comp to a 100% phenolic
Negative temperature area

3—*These two graphs show the heat absorption potential of materials as they are decomposed by heating. The large positive temperature area of ammonium oxalate-50% phenolic material (left) indicates that it is exothermic and will give off more heat than it absorbs. Conversely, the large negative area of trisodium phosphate-50% phenolic material (right) shows that it is endothermic and will absorb more heat than it gives off.*



4—*How temperature affects the weight loss of various materials.*

tial is differential thermal analysis (DTA). In this method two materials, one a "standard" material and the other the unknown, are heated at a fixed rate in separate containers. By comparing the temperature difference between the materials, we can determine their comparative heat absorption potential.

Two examples of how DTA works are shown in Fig 3. A material that is exothermic will have a large area under the curve in the positive temperature area. Conversely, a material that is endothermic will have a large area above the curve in the negative temperature area. Thus, in the case of the materials shown, ammonium oxalate with a phenolic resin binder gives off more heat than it absorbs; such a combination would therefore be of little interest as a heat transfer material, at least over the temperature range examined. However, in the case of phenolic-bonded trisodium phosphate, it is clear that this material absorbs more heat than it gives off.

Breakdown rate important — Although the total amount of heat is important, of at least equal importance is the rate with which the material decomposes or reacts with its environments. A very rapid decomposition may cause the entire heat-absorptive surface to literally explode, absorbing very little heat in the process. On the other hand, if decomposition is too slow much of the material may be mechanically eroded away before any heat absorption occurs.

The variation in breakdown rate of seven potentially useful materials as a function of temperature is given in Fig 4. Each rate varies with the environment and heat flux and usually has to be determined experimentally.

In many reactions the release of a large quantity of one or more gases can enhance the heat protection potential of a material. In such cases the gas can assist in the carrying away of surface heat, lower the convective heat transfer, and, in the case of a gas opaque to infrared heat, block radiative heat transfer to the surface. The heat absorption potential of several materials is given in Table 4 which shows the relative volume of gas generated and the heat absorbed by a material as its temperature is raised from 80 to 8350 F.

TABLE 4—HEAT ABSORBED AND GAS GENERATED BY VARIOUS MATERIALS

Material ↓	Heat Absorbed,[a] Btu/lb	Relative Gas Volume,[b] moles
Hydrogen Gas	120,000	1.0
Organic Plastic $(CH_2)_n$	43,200	0.21
Organic Plastic $(CH)_n$	37,000	0.15
Graphite	30,000	0.08
Water	26,100	0.16
Beryllium	17,800	0.11
Beryllium Oxide	12,700	0.08
Teflon	11,300	0.06
Cellulose	10,400	0.1
Magnesium Oxide	9,900	0.05
Helium	6,350	0.25
Silicon Dioxide	5,050	0.05
Copper	1,600	0.016

[a]Estimated integral specific heats from 80 to 8500 F.
[b]Equilibrium volume of gas generated at 8500 F.
Source: *Gruntfest and Shenker.*

Mechanical effects of state change

If carried far enough, physical and chemical state change can cause some drastic changes in the mechanical structure of materials. For example:

Spalling, or cracking or flaking away, of the material can occur at temperatures below its melting point.

Sloughing, or the separation of thermally softened or weakened pieces, can occur under stresses caused by wind or acceleration. These same stresses can cause runoff of melted material.

Shearing, or loss of material in solid form due to fracture, may be caused by wind shear stresses.

Impact erosion can occur when weakened materials are subjected to the impact of particles or droplets in the gas stream.

From the above it is obvious that the velocity of the environment can be important in determining an ablative material's durability. This is borne out in tests conducted at Aerojet-General Corp. at constant temperature (5000 F) and varying velocity. The material used contained a large amount of powdered ceramic. On melting it was noted

How Electricity and Magnetism Can Be Used to Keep Temperature Down

Engineers have discovered that because of their unique characteristics certain electrical and magnetic effects can be used to control high temperatures. The two outstanding examples of such techniques are magnetohydrodynamics (MHD) and thermoelectricity. Strictly speaking these are not materials techniques; however, they deserve mention here because their operation depends critically on the materials that are used.

Magnetohydrodynamics

Magnetohydrodynamics or MHD is that branch of fluid mechanics that deals with the motion of electrically conductive fluids in the presence of electrical or magnetic fields of force. Thus, MHD can be used to control heat transfer by using a magnetic field force to control the flow of a hot ionized gas away from the surface to be protected.

When using magnetic field effects to control heat transfer it can be shown that:

1. The force of the field diminishes as the square of the distance from the field generating surface.
2. The rate of heat transfer decreases as the field increases.
3. The required field strength critically depends on the conductivity of the medium being controlled.

Since an MHD system requires a reasonable amount of ionized gas and a magnetic field, two problems immediately arise. First, the conditions required to ionize a gas are rather special and a temperature well above 6000 F is usually required. And second, a strong magnetic field requires expensive and very heavy equipment.

The conductivity of the gas can be altered by injecting materials into the gas stream that will further improve its conductivity or ionization rate. For example, seeding the gas with potassium or cesium will produce adequate electrical conductivity at 4000 to 5000 F. The gas can also be further ionized by using glow discharge or microwave breakdown.

It is essential that the materials used for shielding and exterior surfaces be nonmagnetic as well as resistant to the high temperatures encountered (see "Four Advanced Power Generators Pose Hot Materials Problems," M/DE, June '60, p 134). Thus, ceramics and reinforced plastics are generally used.

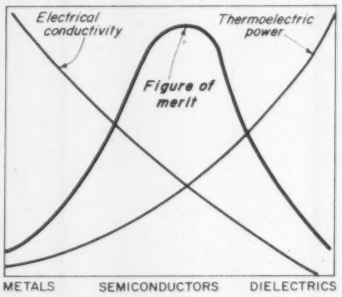
Thermoelectricity

Thermoelectricity is a very interesting way to control heat in that the heat that is absorbed is converted to another energy form —electricity—which can be put to good use as a power source elsewhere in the system.

As the accompanying drawing shows, three general types of materials can be considered for thermoelectric generation: metals, semiconductors and dielectrics. For efficient power generation (and therefore efficient heat absorption) the hot junction of the thermopile should operate at 1100 F or higher. To date, no materials have been developed that can be used much over 2000 F, and this is currently the limiting temperature for the technique.

Although most thermoelectric devices use either the Seebeck or Peltier effect for optimum heat protection, it may be desirable to combine the two. Thus, some of the power obtained with the Seebeck effect can be fed back into a Peltier junction to provide a cooler surface. The effectiveness of such a system would, of course, depend on the relative efficiencies of the two thermoelectric devices.

The further growth of thermoelectric technology depends on our ability to adjust the number of free electrons in semiconductor materials. This is because: 1) the output voltage of any thermoelectric material is inversely proportional to the number of free electrons; and 2) the electrical conductivity of the material is directly proportional to the number of free electrons. Thus, a compromise between high voltage and high electrical conductivity must always be made.



Thermoelectric properties *vary with type of material. Materials selection is also determined by temperature of operation. Some semiconductors have proved satisfactory up to 1100 F. Certain modified insulators can operate to 1800 F. And one of the newest mixed-valence materials, samarium sulfide, has a good figure of merit up to 2000 F (figure from* Steele*).*

that the ceramic formed a protective layer on the surface which prevented further extensive heat absorption and withstood test conditions. However, at increasing velocity the protective shield was swept away, thus continuously exposing a fresh surface to further heat absorption and producing eventual material failure.

The way in which an ablating material is manufactured and the ways it is exposed to erosive gases can also cause an appreciable difference in ablation resistance. Factors such as fiber orientation, resin content, and curing pressure and temperature must be carefully considered and examined.

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CFE Plastic Used for Blood Filter Windows

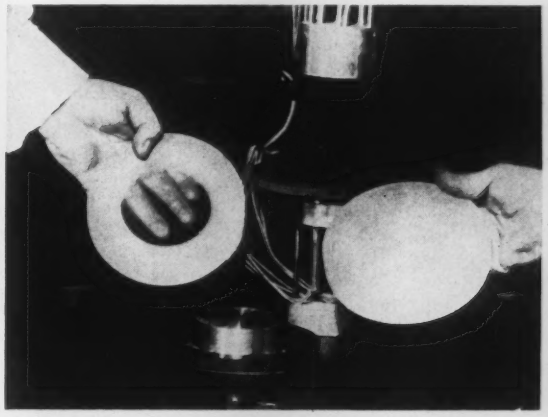
Because halofluorocarbon plastic offers an excellent combination of properties it has replaced glass and transparent acrylics in windows of an arterial blood filter used in open heart surgery.

Conventional window materials require tedious "cold" sterilization because they cannot withstand the effects of steam sterilization and they must be coated with silicone to avoid chemical damage to the blood.

The Kel-F brand halofluorocarbon used withstands repeated autoclaving without changing dimensions or losing transparency. The plastic, made by Minnesota Mining & Mfg. Co., does not affect the blood chemically, and can be accurately machined.

The filter, made by Rao Instrument Co., Brooklyn, N. Y., consists of two 6-in. dia disks with a thin, clear window in their centers. A 60-mesh stainless steel filtering screen is mounted between them. Transparency is essential for detection of dangerous air bubbles in the blood stream. Any bubbles that develop are caught by the filter and vented through two stainless steel valves.

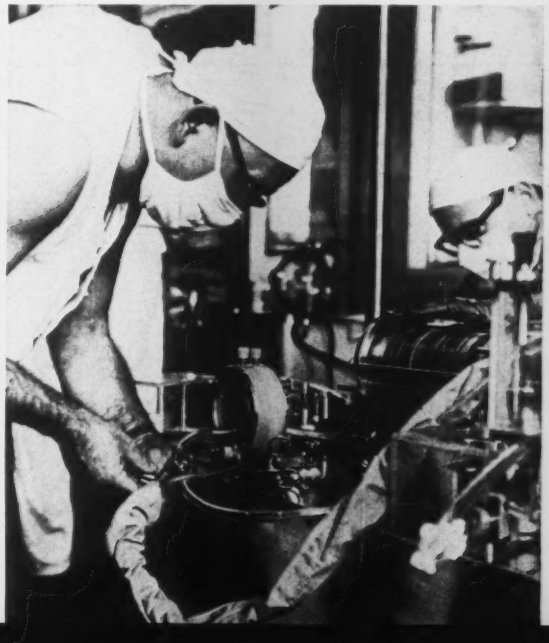
1 ***Cutting the window area*** *to ¼ in. thickness in the plastic disk. The disk is 1 in. thick and 6 in. in dia and can be successfully machined to very close tolerances.*



3 ***The transparent disk*** *has been heat treated and the opaque one has not. Two disks are used in each filter to enclose a sheet of 60-mesh stainless steel screen.*

2 ***Postheating and quenching*** *makes the plastic window permanently transparent. Here the quenching plate is being inserted in the heater before treating a disk.*

4 ***The blood filter*** *is connected to the heart-lung machine just before surgery begins. Oxygen bubbles are trapped in the filter and expelled through the two vents at the top.*



Design with High Strength Cold Rolled Austenitic Stainless Sheet

Properties of highly cold reduced austenitic stainless sheet steel have been collected from a variety of sources. These data give engineers information covering a wide temperature range.

by D. B. Roach and A. M. Hall, *Battelle Memorial Institute*

■ All austenitic stainless steels work harden during cold rolling. Many, however, do not exhibit an acceptable combination of strength and ductility in the cold rolled condition; while yield and tensile strengths increase rapidly, ductility drops drastically. Thus, austenitic stainless steels cold rolled to high strength levels have virtually no ductility. AISI types 302, 304, 321 and 347 are good examples.

Some stainless steels—such as AISI type 301 — are specifically designed for use in the heavily cold rolled condition; in such steels ductility does not decrease as rapidly as it does in type 302, for example. Acceptable ductility levels combine with high strength.

COMPRESSIVE PROPERTIES OF TYPE 301[a] (at Room and Elevated Temperatures)

FULL-HARD

Temp, F ↓	Longitudinal		Transverse	
	Yld Str (0.2% offset), 1000 psi	E_c, 10^6 psi	Yld Str (0.2% offset), 1000 psi	E_c, 10^6 psi
AS ROLLED				
70	120	24.5	194	28.5
400	101	24.1	189	26.2
600	97	22.0	180	23.5
800	95	21.6	152	22.5
900	97	21.2	148	21.6
1000	85	20.5	125	21.2
STRESS RELIEVED[b]				
70	165	26.4	214	28.3
400	135	26.0	199	26.7
600	124	24.7	191	25.5
800	105	22.1	167	21.6
900	97	21.0	157	20.2
1000	84	20.3	137	20.3

[a] 0.032-in. sheet; cold rolled 40%; Rockwell hardness C41.
[b] 8 hr at 800 F; Rockwell hardness C45.

EXTRA-HARD

Temp, F ↓	Longitudinal		Transverse	
	Yld Str (0.2% offset), 1000 psi	E_c, 10^6 psi	Yld Str (0.2% offset), 1000 psi	E_c, 10^6 psi
AS ROLLED				
70	181	23.1	286	29.8
400	172	20.3	264	27.6
600	169	18.2	248	26.2
800	153	17.8	220	23.2
900	145	17.3	202	23.1
1000	96	15.7	141	18.3
STRESS RELIEVED[b]				
70	236	27.5	323	31.8
400	204	26.0	286	29.4
600	173	23.4	258	27.7
800	146	21.2	232	24.6
900	140	20.1	192	22.1
1000	87	16.6	117	18.1

[a] 0.027-in. sheet; cold rolled 65%; Rockwell hardness C50.
[b] 8 hr at 750 F; Rockwell hardness C52.

COMPOSITION OF HIGH-STRENGTH COLD-ROLLED AUSTENITIC STAINLESS STEELS

Type	Designation	C	Mn	Si	S	P	Cr	Ni	N	Mo	V
17Cr-7Ni	AISI 301	0.08-0.20	2.00 max	1.00 max	0.03 max	0.03 max	16.0-18.0	6.0-8.0	—	—	—
17Cr-7Ni	MicroMach (301 N)[a]	0.08-0.12	2.00 max	1.00 max	0.03 max	0.03 max	17.0-17.6	6.0-6.5	0.10-0.15	—	—
Cr-Ni-Mn	AISI 201	0.15 max	5.5-7.5	1.00 max	0.03 max	0.06 max	16.0-18.0	3.5-5.5	0.25 max	—	—
High Mn	USS Tenelon[b]	0.10	14.5	—	—	—	17	—	0.40	—	—
High Mn	USS 17-5 MnV[b]	0.10	15.0	0.50	—	—	17.0	5.0	0.35	2.0	0.75

[a]Washington Steel Corp., Jones and Laughlin Steel Corp. [b]United States Steel Corp.

Some common problems—In the heavily cold worked condition, austenitic stainless steels have limited formability. They can be bent, however, if reasonably generous radii are used, and they can be subjected to a wide variety of other mild forming operations. Because these steels derive their strength from cold working, the only permissible heat treatment is a low temperature stress relieving operation. Higher temperature treatments such as annealing result in a loss of strength. The effect of temperature is particularly important in welding; austenitic stainless steels are readily weldable but strength is lowered in the heat affected zone.

Reinforcing the weldment can compensate for strength reduction. A common method: after butt welding hard-rolled sheets by the tungsten inert-gas arc process, spot weld a doubler on the joint. In this way joint efficiencies up to 100% are readily obtained.

When using heavily cold rolled stainless sheet, you should note that compressive yield strength in the longitudinal direction is considerably lower — perhaps by 45%—than the longitudinal tensile yield strength in the as-rolled condition. This characteristic, sometimes called the Bauschinger effect, depends on the rolling conditions, stress relief and composition. In the transverse direction and the stress relieved condition, however, compressive and tensile yield strengths are about equal.

Most of the cold rolled stainless steels are readily available in standard gages and in widths up to 48 in. Width is usually restricted to about 24 in. max when thickness is less than 0.01 in. The high strength properties are available in sheet and strip of approximately 0.080 in. max thickness.

17 Cr–7 Ni types

AISI type 301 stainless steel (see table above for composition) was specifically designed for use in the cold rolled condition. High strength is produced by cold rolling, and ductility does not decrease to the point where the steel is no longer formable. Although the allowable composition range is broad, producers tend to melt this steel within narrow limits; usual practice is to melt to a composition of approximately 0.08 to 0.12% carbon, 6.5 to 7.5% nickel, and 16.5 to 17.5% chromium.

Structure—In the annealed condition the alloy is primarily austenitic and carbon is in solid solution. Small amounts of delta-ferrite may also be present making the steel slightly magnetic with a permeability of 1.02. After cold rolling the austenitic matrix tends to transform to a magnetic phase variously referred to as martensite, pseudomartensite and ferrite, and permeability may increase to a value of 14.

The austenitic transformation causes considerable strengthening cumulative with strengthening achieved by the normal strain

STRESS-RUPTURE PROPERTIES OF STRESS RELIEVED TYPE 301

	FULL-HARD[a]			EXTRA-HARD[b]	
Stress, 1000 psi	Rupture Time, hr	Elong (in 2 in.), %	Stress, 1000 psi	Rupture Time, hr	Elong (in 2 in.), %
800 F					
162	10 min	3.5	200	35 min	8.0
161	1.5	4.0	195	8	3.5
150	18.5	6.5	190	28.5	10.0
140	64.5	5.0	185	53.5	3.0
130	185	5.5	165	66	9.0
			150	172.5	4.0
900 F					
110	15	5.5	110	5.75	11.5
100	26	5.0	95	23	17.0
95	51	3.0	85	61.5	3.0
90	68.5	3.0	70	135	5.0
80	243	5.0			
1000 F					
80	4	9.0	80	2	8.5
70	17	10.0	70	3.75	6.5
65	51.5	3.5	60	18	10.0
55	163.5	7.5	45	52	22.5
1200 F					
55	1.5	20.5	70	5 min	22.0
50	4.25	7.0	55	25 min	23.5
45	9	11.0	30	17	48.0
40	24.5	17.5	20	56	22.0
30	269.5	10.5	15	191	64.0

[a]0.032-in. sheet; stress relieved 8 hr at 800 F; R_c 44.5.
[b]0.0275-in. sheet; cold rolled 65%; stress relieved 8 hr at 750 F; R_c 52.5.

ROOM AND ELEVATED TEMPERATURE TENSILE PROPERTIES

FULL-HARD TYPE 301 (Transverse)

Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, % (in 2 in.), %	E_o, 10^6 psi
AS ROLLED[a]			
198	146	20.2	31.3
177	149	1.5	23.3
167	137	2.3	23.6
157	126	3.1	21.8
148	121	2.6	23.0
121	96	4.5	19.3
102	74	7.1	16.5
84	59	8.3	14.0
STRESS RELIEVED[b]			
201	176	19.2	30.9
181	160	1.8	26.6
174	148	1.8	26.2
160	134	2.8	22.8
145	123	3.1	19.2
122	96	4.5	18.2
101	74	6.3	16.0
84	64	8.9	11.3

[a]0.02-in. sheet; cold rolled 40%; Rockwell hardness C43.
[b]Same as [a]; stress relieved 8 hr at 800 F; Rockwell hardness C44.5-45.

EXTRA-HARD TYPE 301 (Transverse)[a]

Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %	E_o, 10^6 psi
AS ROLLED[a]			
279	241	3.8	33.5
269	228	1.5	27.6
254	206	1.8	25.8
229	185	3.1	24.5
199	144	4.3	25.5
120	76	11.0	14.0
94	58	14.0	10.1
76	44	12.3	10.9
STRESS RELIEVED[b]			
298	274	—	34.9
272	246	2.0	30.2
257	230	1.8	27.1
226	178	3.4	26.6
198	156	3.4	21.7
119	73	10.1	14.8
94	59	10.9	10.2
75	49	11.6	10.0

[a]0.020-in. sheet; cold rolled 65%; Rockwell hardness C51.5.
[b]Same as [a]; stress relieved 8 hr at 750 F; Rockwell hardness C53.5.

FULL-HARD TYPE 201 (Longitudinal)

Temp, F ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %
Room	195	173	10.5
300	196	166	4.0
500	184	154	4.0
700	171	140	5.0
900	152	120	7.5
1000	131	101	6.5
1100	99	81	10.0

USS TENELON (Transverse)[a]

Temp, F ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, (in 2 in.), %
75	258	236	4.8
400	212	186	2.0
600	195	164	4.5
800	168	135	5.0
1000	150	128	2.7
1200	90	70	4.1

[a]0.02-in. thk; cold reduced 60%; stress relieved at 800 F for 2 hr.

USS 17-5 MnV (Transverse)[a]

Temp, F ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %
75	247	223	7.0
300	227	200	6.7
500	213	182	6.3
700	196	166	7.6
900	181	153	5.9
1100	146	118	2.1
1200	111	91	2.4

[a]0.02-in. thk; cold reduced 40%; stress relieved at 1100 F for 2 hr.

hardening of austenite during cold work. In the full-hard (cold reduced 40 to 50%) and extra-hard (cold reduced 50 to 65%) conditions this type of steel has attractive strength properties because of the dual hardening mechanism.

Heat treatment—In addition to the availability of standard tempers ranging from soft to extra hard, 17% chromium-7% nickel steels are also available in the stress relieved condition for these tempers. Full hard sheet is frequently given a stress relieving heat treatment at 800 F for times up to 8 hr; extra hard sheet is commonly stress relieved at 750 F for up to 8 hr. Stress relieving increases strength and reduces anisotropy (property differences due to direction of testing).

MicroMach, a modified type 301—In this proprietary grade controlled composition allows a good combination of strength and ductility to be maintained over a wide range of cold reductions. Good strength is maintained at elevated temperatures; 100-hr rupture stresses at 800 and 1200 F are 134,000 and 22,500 psi, respectively.

In the extra hard condition, the material is somewhat less magnetic than type 301 stainless. Magnetic permeability is about 5 as compared to about 10 for similarly treated type 301 stainless

Steels with reduced nickel content

Type 201—A low nickel substitute for type 301, this grade currently represents only a small fraction of total austenitic stainless production. Properties are similar to those of type 301, and permeability increases in a similar manner.

Tenelon and 17-5 MnV—These two steels are proprietary grades produced by the United States Steel Corp. Tenelon retains strength at temperatures up to 1000 F and above. The 17-5 MnV alloy differs from Tenelon in that it contains nickel to promote an austenitic structure and molybdenum and vanadium for increased strength at elevated temperatures.

The interesting property of these two steels is this: even after cold reductions as high as 60%, the austenitic structure does not transform to martensite. Magnetic permeability at this degree of cold work is usually less than 1.02.

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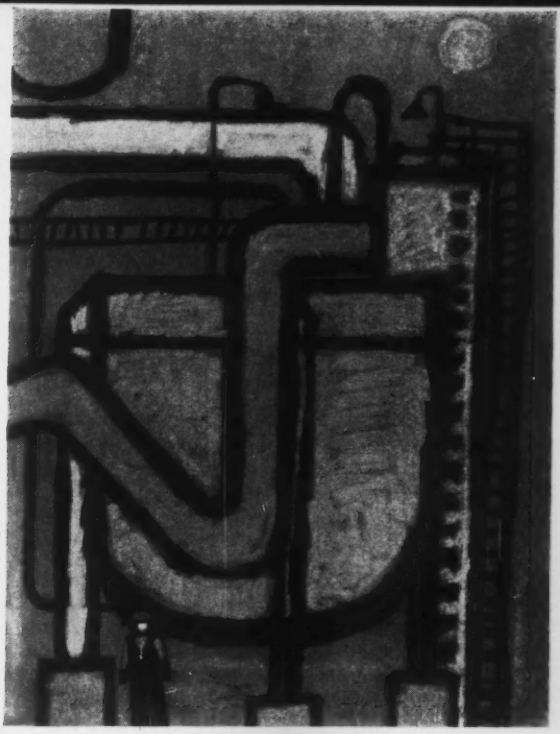

Chemical Process Equipment:

What Materials Are Next?

Coming years will see greater use of: • *Stainless steel, high alloys, titanium and other new materials to meet higher temperatures and unusual corrosive environments* • *Aluminum for structures exposed to atmospheric corrosion* • *Reinforced plastics for lightweight, low cost ducts, tanks, etc.* • *Plastics pipe for long life, low maintenance*

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

Engineers and designers in the chemical process industries are faced with a great range and incidence of materials selection problems. Literally hundreds of different pieces of equipment are required to process the complex variety of chemicals, foods, petroleum products, and the many other products of the chemical process industries. Not much of this equipment is available "off the shelf;" most of it has to be specially designed to meet an exacting set of service conditions. Needless to say, the materials selection problems are formidable. In general, these problems stem from the need to:

- Design equipment to meet an ever increasing range of corrosive media, many of which were rarely heard of a decade ago.
- Design equipment to withstand higher operating temperatures and pressures resulting from today's trend to complex processes and higher manufacturing efficiencies.
- Keep initial material and fabrication costs down without increasing the danger of equipment failure.
- Reduce maintenance and expensive down-time.
- Preserve product purity and avoid contamination of equipment.

This tough set of requirements has spurred the development of many new engineering materials and better utilization of conventional materials. Because of the vast number of materials used in chemical process equipment it is impossible to cover here all of the important materials applications now taking place. This is why many important materials already widely accepted for use in chemical process equipment will *not* be mentioned in this article. Among the missing will be such basic materials as brass, lead, wrought iron, cast iron, and many of the corrosion resistant high alloys. (However, all important materials used in chemical process equipment have been covered in M/DE in recent years; see selected bibliography on p 114.)

Thus it is the purpose of this report to spotlight what users of engineering materials seem to feel are the most significant trends today in the chemical process industries.

Chemical Process Equipment

STAINLESS STEELS, Other Corrosion Resistant

Types 304 and 316 increasingly popular for general use

New plants turn to higher alloys

Cathodic protection looks promising for above-ground structures too

■ Because of the trend toward more rigorous operating conditions, materials engineers in the chemical process industries are increasingly turning toward special alloys to solve their materials problems. Stainless steels have long been the workhorse of these industries, and current indications are that they, as well as the higher alloys, will be used in even greater quantities in years to come. When selecting materials for process equipment, almost all users think not so much of the initial cost of materials, but of how much they will cost over the life of the equipment. Thus, even high alloys often prove cheaper in the long run because they last longer and reduce maintenance costs and expensive downtime.

Types 304 and 316 stainless are most popular

Because of their all-around corrosion resistance, types 304 and 316 are the most widely used stainless alloys in the chemical process industries today. Both types are equally satisfactory for many applications; however 316 is superior to 304 in some environments, particularly those that produce pitting type attack. In general, 316 is more popular for chemical processing equipment because, as one user puts it, "It is suitable for 99% of our applications." However, 316 sheet costs considerably more than 304—81¢ per lb vs 55¢ per lb for 304.

There is a trend now toward using more of the low carbon grades—304L and 316L—to minimize carbide precipitation problems. Welding or operation in the range of 800 to 1500 F tends to precipitate chromium carbide. This can promote corrosion in certain areas by some acids, notably acetic, sulfuric and hot nitric. The problem was first solved by adding titanium and columbium, as in types 321 and 347. But a more recent solution has been to keep carbon content below 0.03%, as in types 304L and 316L. The lower carbon may cut strength a little but work is now under way to eliminate this drawback. It is also reported that if 304L is held at high temperature long enough (several hundred hours) some carbide precipitation may occur; under this circumstance the stabilized grades (321 and 347) are preferred.

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Alloys Used More Widely

Indications are that some users may be tending to overspecify 304L and 316L just to be on the safe side. One materials engineer says, "If you're not welding or operating at high temperatures, why use the low carbon grades?" This same user points out that 304 or 316 are perfectly all right for most applications provided that you are careful during welding and if you make sure that your shop knows the best way to fabricate the material.

Other stainless trends

After 304 and 316 there appears to be a big gap in the volume of other grades of stainless used in much chemical process equipment. One large user of 316 reports that 310 is being used for some high temperature applications, 317 is used occasionally, and 302, 321, 347, and the 200 and 400 series are used very little.

However, the same is not as true for food processing equipment. One application engineer says that although some people assume that the 200 series stainless steels with lower nickel content are inferior to the 300 series, "this may not be true." Although food processing engineers still have a conservative attitude towards the 200 series, it appears that these steels may perform satisfactorily in some applications.

There is a definite trend in food processing towards greater use of clad materials. This is especially true where good heat distribution is needed. Solid stainless does not distribute heat well but when it is used over a more conductive material this problem can be eliminated. A popular composite right now is "double armor," composed of a carbon steel sheet sandwiched between two sheets of stainless steel. Copper is sometimes used instead of the carbon steel but it adds to cost.

There is also growing use of stainless steel for condenser tubing. Stainless is replacing such materials as brass, copper and cupro-nickel because it has better corrosion resistance and cuts down replacement. It is reported that stainless can be used for over 30 years in some applications.

Apart from corrosion resistance, an important property of stainless for food processing equipment is its excellent bacteria cleanability. Steels for food equipment are specified with very smooth, highly finished surfaces. Normally a No. 4 finish is specified for dairy equipment, and engineers were thinking of even going to a higher grade finish such as a No. 7. However, a recent study shows that a standard finish such as 2B cleans just as well as polished finishes such as 3, 4 and 7.

Stainless steel vs aluminum

There does not appear to be much competition between stainless steel and aluminum for the older and more conventional items of processing equipment. And as far as the newer applications go, each material appears better for handling different media. If anything, aluminum has a disadvantage in that, unlike stainless steel, it is not resistant to some of the caustic fluids used for cleaning. However, this problem can be easily avoided.

There is one area which is becoming increasingly important where the two materials are often competitive —cryogenic applications. This area will be explored in a special report in our July issue.

Other alloy trends

▸ Incoloy alloy is finding greater use for petroleum processing equipment. Along with 310, 316 and 347 stainless it is now being used for tubing in the furnace of a new napthalene plant.

▸ A 60 chromium-40% nickel alloy has proved that it can outlast previously used materials by 10:1 in molten ash residues from Bunker C oil. Based on this experience, the alloy appears suitable for petroleum processing applications involving the burning of oil and the danger of vanadium pentoxide corrosion.

▸ A 42 nickel-21.5% chromium alloy (Nionel) has found its first large-scale use in a pilot plant evaporator heat exchanger. The user believes that this alloy is the coming material of construction for phosphoric acid equipment.

What About Cathodic Protection?

Although cathodic protection has been used with considerable success on underground piping and structures, comparatively little work has been done in the past on the protection of processing equipment. However, according to a recent report by a special task group of the National Association of Corrosion Engineers, cathodic protection appears to have considerable merit for some applications. NACE investigators report that, "Obviously, cathodic protection is not a cure-all for all the corrosion evils of the chemical industry. However, in numerous cases it has proved to be an effective corrosion control weapon." They go on to point out that care is needed, principally because the use of cathodic current on passivé metals can possibly cause cathodic corrosion under some conditions.

Although little information has been published on cathodic protection of process equipment, NACE's task group turned up several interesting applications, including:

▸ A 316 stainless steel cooling coil operating in a sodium hypochlorite solution. Ordinarily this unit failed in two to three months. When cathodically protected, its life was stretched out to more than five years.

▸ Copper steam coils operating in zinc chloride and ammonium chloride concentrating tanks. These coils were found to cause product contamination and discoloration. Installation of zinc anodes and use of impressed current controlled corrosion, improved product purity, and produced annual savings of $1200.

▸ Lead pipe coils used in barium chloride treatment tanks. These coils were subject to severe corrosion; using zinc anodes doubled their life.

Chemical Process Equipment

ALUMINUM GAINING FAVOR for Maintenance-Free

Users find that aluminum preserves product purity . . . resists many corrosives . . . conducts heat well

■ As noted in a recent article in M/DE ("Selecting Aluminum Alloys for Process Equipment," May '60, p 121), aluminum alloys are becoming increasingly popular for processing chemicals, petroleum products, food and pharmaceutical products. Carbon and stainless steels are still the most common structural materials in the chemical process industries but aluminum is making slow but steady inroads.

Aluminum preserves product color, purity

Like the stainless steels, aluminum alloys are proving quite advantageous in many processes where product color and purity must be preserved. Practically all aluminum salts are white and colorless, and the metal is nontoxic and resistant to attack by many foods. Engineers are finding that aluminum alloys can be used to handle such materials as cosmetics, essential oils, foods, inorganic chemicals, pharmaceuticals, plastics and related products.

Typical of the applications where aluminum is currently being used to preserve product purity are cottage cheese vats, butter churns, distilled water storage and distribution systems, and adsorption tanks used for making chloromycetin and streptomycin. One company reports that it is using a fair amount of aluminum for storing refined tall oil and fatty acids. Carbon steel could handle the acids but because discoloration occurs a switch was made to aluminum with good results. The same company is using aluminum for storage hoppers handling dry chemicals to prevent discoloration.

Aluminum is also being used in significant quantities in the processing and handling of beer. In addition to making all its kegs of aluminum, one Canadian brewery is also using the metal for a large assortment of tanks and equipment used in the malting, fermenting and brewing process (though not for the actual brew kettle) to preserve product purity and taste.

Aluminum reduces maintenance of outdoor equipment

Because of its well-known resistance to atmospheric corrosion, aluminum is gaining favor in the chemical process industries for outdoor structural applications, mainly as a replacement for carbon steel structures which have to be painted and require periodic maintenance. The oxide coating that forms on alumi-

Other Corrosion Resistant Materials: A Bibliography of Recent M/DE Articles

In addition to the materials highlighted in this special report, recent articles in M/DE have covered in detail just about every new and standard corrosion resistant material used in the process industries. As an aid to materials engineers seeking more information here is a selected list of articles on process industry materials which we have published in the past five years:

Aluminum

Aluminum Alloy Castings (Manual), Feb '58, p 125.
The New 5XXX Aluminum Alloys—Strong and Weldable, July '59, p 91.
Selecting Aluminum Alloys for Process Equipment, May '60, p 130.
Wrought Aluminum Alloys (Manual), Jan '56, p 109.

Beryllium

Beryllium: A New Engineering Material, Mar '59, p 91.
Properties of Wrought Beryllium, *Materials Selector Issue*, Mid-Nov '60, p 150.

Carbon and Graphite

Graphite: How It Compares With Metals and Ceramics, June '59, p 88.
Graphite Suitable for Many Uses, Mar '60, p 146.
High Temperature Fibers, Felts Now Made of Pure Graphite, May '59, p 149.
How Graphite Performs at High Temperatures, May '56, p 126.

Cast Irons

Alloy Cast Irons Can Solve Tough Problems, Oct '57, p 141.
Gray Iron Castings (Manual), Oct '56, p 121.
Guide to Ferrous Castings (Manual), Oct '60, p 127.
Severe Abrasion? Try White or Chilled Cast Iron, Aug '57, p 99.

Ceramics and Cermets

Improved Silicon Carbide for High Temperature Parts, Oct '56, p 93.
Inorganic Block Insulation, Apr '56, p 163.
New Alumina-Type Cermets, Feb '58, p 112.
New Developments in Ceramics, May '58, p 121.
Properties of Commercial Refractory Oxides, Dec '56, p 135.
Silicon Nitride Refractory, Jan '58, p 115.
Why and Where to Use Carbide Base Cermets, Feb '59, p 79.

Coatings, Finishes

Bituminous Coatings, Aug '59, p 100.
Electroplated Coatings (Manual), July '56, p 117.
Epoxy Coatings for Metal Products, Apr '57, p 130.
Furane Coatings, Oct '59, p 90.
Glass Coatings: A Good Way to Protect Metal, Mar '58, p 106.
Metallic Coatings for Corrosion Prevention, Feb '58, p 147.
Organic Coatings for Metal Products (Manual), Mar '59, p 113.
Phenolic Coatings for Metal Products, Jan '57, p 106.
Porcelain Enamels and Ceramic Coatings (Manual), July '58, p 103.
Properties of Porcelain Enamels, July '60, p 97.
Silicone Coatings for Metal Products, Feb '57, p 112.
Tough, Chemical Resistant Urethane Coatings, June '59, p 80.
Vinyl Coatings for Metal Products, Mar '57, p 130.

Columbium

Columbium and Its Uses, May '57, p 131.
Properties of Wrought Columbium, *Materials Selector Issue*, Mid-Nov '60, p 133.

Copper and Its Alloys

Continuous Cast Bronze Shapes, Feb '56, p 108.
Corrosion Ratings of Copper Alloys, Dec '60, p 129.
Cupro-Nickels Offer Corrosion Resistance and Hot Strength, May '58, p 114.
Silicon Bronzes, Nov '59, p 112.
Wrought Cupro-Nickels, Apr '59, p 127.

Corrosion Resistant Materials (general)

Operation

num is an effective barrier against the elements, and even though the surface may become dulled, no significant attack occurs and the surface requires little maintenance. It is not materially affected by gases containing sulfur, and sea and salt atmospheres are not harmful under almost all conditions. Typical of current weatherproof applications are handrails, stair treads, siding, roofing, window frames, catwalks, ladders, gratings and coverings for thermal insulation.

Aluminum is used to handle certain chemicals

Aluminum is highly resistant to many common chemicals, petroleum products and foods. However, it is not a panacea for all corrosion problems; there are some corrosive media that it can handle very well and others that it cannot handle at all. Because of the relative newness of aluminum in the process industries many engineers are still approaching some applications with caution.

One recent successful application is in the production of hydrogen peroxide. Last year Laport Chemicals of England installed the world's largest hydrogen peroxide plant, making extensive use of aluminum. Aluminum was selected because its passivity prevents peroxide decomposition during processing.

Recently it has been discovered that aluminum alloys with good resistance to high temperature, high purity water can be obtained by adding alloying elements such as iron, nickel, cobalt, rhodium or copper. Aluminum powder parts containing additions of iron and nickel also show promise for corrosion resistant applications. These parts have higher strength at elevated temperature than wrought alloys of similar composition.

In general, users have been alert to the possibilities of aluminum for corrosion resistance applications. Although the majority of applications have worked out successfully, there have been some misapplications. One user installed nine aluminum items in a urea plant and because of failures has had to switch to stainless steel and some carbon steel. The same company has had poor experience with aluminum storage tanks containing ammonium nitrate and aluminum heat exchanger tubes used with ammonium carbonate solution.

High thermal conductivity valuable for heat exchangers

Because of its high thermal conductivity and combination of light weight and corrosion resistance, aluminum is proving to be an ideal material for some heat exchanger and condenser tube applications. Engineers note that it is particularly valuable in petroleum equipment where its high resistance to gaseous and liquid hydrocarbons, as well as hydrogen sulfide and carbon dioxide, can be utilized. Also, since aluminum surfaces resist fouling they help to keep up operating efficiency and reduce maintenance. Furthermore, aluminum does not cause product discoloration, sludging or decomposition.

Among the important current uses in the petroleum industry are condensers, heat exchangers and reboilers used with distillation columns for separating light petroleum products. Other uses include oil-to-oil exchangers and compressor aftercoolers and intercoolers. Because of its good properties at low temperatures, aluminum is extensively used in low temperature petroleum processing plants.

Engineers note that impurities in untreated water can cause problems in aluminum heat exchangers. However, a cladding of 7072 alloy can help to protect the base metal, and other forms of cathodic protection

The Chemistry of Materials Failure, Dec '60, p 99.
Clad Metals, *Materials Selector Issue*, Mid-Nov '60, p 406.
Materials for Gaskets, Packings and Seals (Manual), Dec '59, p 111.
Mechanical Tubing, Dec '57, p 127.
New Ways to Combat Corrosion, Sept '59, p 94.

Elastomers

The Fluoro-Elastomers: Latest Weapon Against Heat and Fluids, July '57, p 90.
A Guide to Synthetic Rubbers (Manual), Sept '57, p 129.
How to Protect Metals With Elastomeric Linings, Aug '57, p 94.
Selecting Silicone Rubbers: Part 1, May '57, p 140; Part 2, June '57, p 114.
Where to Use Hypalon, Jan '57, p 96.

Fabrics and Fibers

Bonded Fabrics, Feb '56, p 103.
Ceramic Fiber: Seven Forms and How to Use Them, Oct '57, p 124.
Engineer's Guide to Industrial Textiles (Manual), July '59, p 115.
Selecting Materials for High Temperature Filters, Nov '59, p 108.
Treated Felts, Dec '60, p 90.

Glass

Fused Silica, Feb '57, p 106.
How to Select and Specify Glass (Manual), Nov '56, p 139.

High Alloy Castings

Stainless Steels—Cast, *Materials Selector Issue*, mid-Nov '60, p 70.
Heat Resistant Alloys—Cast, *Materials Selector Issue*, mid-Nov '60, p 74.

Lead

Clad Metals, *Materials Selector Issue*, mid-Nov '60, p 406.
Lead and Its Alloys—Cast, Wrought, *Materials Selector Issue*, mid-Nov '60, p 126.

Molybdenum

Molybdenum Alloys: When to Use Them, Nov '56, p 114.
An Up-To-Date Report on Molybdenum Metal, July '60, p 104.

Nickel

New Nickel Alloys for High Temperature Service, Sept '57, p 115.
Nickel Alloy Stands Up to Severe Corrosion Conditions, June '60, p 9.
9% Nickel Steel is Strong, Weldable, Easily Formed, Oct '59, p 135.

Plastics

ABS Plastics are Low Cost, Tough, Resistant, Moldable, Dec '60, p 188.
A New Look at Nylon Plastics, Dec '58, p 94.
Engineer's Guide to Plastics (Manual), Feb '59, p 103.
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Plastics Pipe, Aug '56, p 100.
Polypropylene—A Promising New Plastic, Jan '58, p 110.
Selecting Plastics Laminates for Industrial Use (Manual), Feb '57, p 121.
Selection and Design of Fluorocarbon Plastics (Manual), June '57, p 129.
What Users Think of Polypropylene, Dec '60, p 117.
What's New in Plastics for Engineering Uses, Apr '59, p 105.

Rare Metals

Present and Future Uses of Rare Metals, Jan '56, p 81.
Rare Earths: Sixteen New Metals are Ready for Use, Nov '60, p 134.

Stainless Steel

The New Stainless Steels, Apr '56, p 137.
Selecting Mechanical Finishes for Stainless Steel, Sept '57, p 110.
17-4 PH Castings Strong and Corrosion Resistant, July '57, p 105.
Stainless Castings With Unusual Hot Strength, Mar '58, p 104.

Titanium

Resistance of Titanium to Chemical Corrosion, Feb '60, p 121.
Titanium (Manual), Oct '57, p 149.
Titanium Alloys Resist Reducing Acids, June '59, p 115.
Where Industry Is Using Titanium, May '56, p 112.

Wrought Iron

Close Tolerance Wrought Iron Tubing, Feb '57, p 116.
Ingot and Wrought Irons, *Materials Selector Issue*, mid-Nov '60, p 43.

Zinc

Hot Dip Coatings, *Materials Selector Issue*, mid-Nov '60, p 334.
Preplated and Precoated Metals, '60-'61 *Materials Selector Issue*, mid-Nov '60, p 347.

Chemical Process Equipment

REINFORCED PLASTICS
The New Material of

Users are impressed with its low, long-term cost and its light weight, ease of handling and low maintenance. Another trend: more plastics pipe.

■ Because this article is concerned only with important materials trends it is not possible to go into detail on all of the plastics used for chemical process equipment. But let's look at those materials which are gaining a strong foothold and are being increasingly used in large quantities.

Reinforced plastics: why they are being used

Of all the recent plastics adopted by the chemical process industries in recent years, one of the most important has been glass-reinforced laminates. The rapid acceptance of these materials has been mainly due to their:

- Low cost over the life of the equipment.
- Superior resistance to certain corrosive materials.
- Light weight and strength.
- Low fabrication, shipping and erection costs.

Although epoxy laminates are important in certain applications, the lower cost glass-reinforced polyester laminates have caught on to a much greater extent and are currently being used in very large quantities.

Depending on composition, the weight of glass-reinforced polyesters is only one-fourth to one-third that of steel—an important factor for many structural applications. Because of their relatively low thermal expansion and conductivity and good dielectric properties the materials provide good insulation against heat and electricity. They also have a low rate of water absorption and good resistance to vapor transmission. Against these advantages it should be noted that most polyesters are combustible; however, certain grades can be made self-extinguishing and fire retardant.

Glass-reinforced polyesters are noted for their excellent mechanical properties which, if the reinforcement is properly oriented, approach those of cold rolled steel. Some problems were encountered with early applications primarily because users did not evaluate properties of the materials carefully enough. However, enough data on the behavior of the materials have been accumulated so that there is little excuse for poor design. For example, the fall-off in strength of laminates when exposed to liquids is predictable and is found to level off at a relatively high value after a certain length of exposure, provided that careful attention is paid to materials selection and fabrication. Glass-reinforced structures are more rapidly attacked when they are highly stressed. Thus, to be on the safe side engineers are using safety factors of 10 or 15 on large or highly stressed structures (such as liquid-containing tanks).

In analyzing the chemical resistance of glass-reinforced polyesters the user should bear in mind that a great many polyesters are available. In general, these resins can be divided into five broad types: high, medium and standard chemical resistant types, a fire and chemical resistant type, and a solvent resistant food grade.

Users report (the author is indebted to R. E. Gackenback of American Cyanamid Co. for the following information) that glass-reinforced polyesters have good resistance to both aging and weathering by continuous outdoor exposure. Similarly, they are little affected by fresh, brackish and sea water. Their resistance to dilute and moderate concentrations of nonoxidizing mineral acids is excellent at room temperature but drops off as temperature is increased. In general, only dilute solutions of oxidizing acids can be handled by the polyesters; however, they provide more resistance to dilute chromic and nitric acids and sodium hypochlorite than the phenolics, furanes or epoxies.

Reinforced plastics: where they are being used

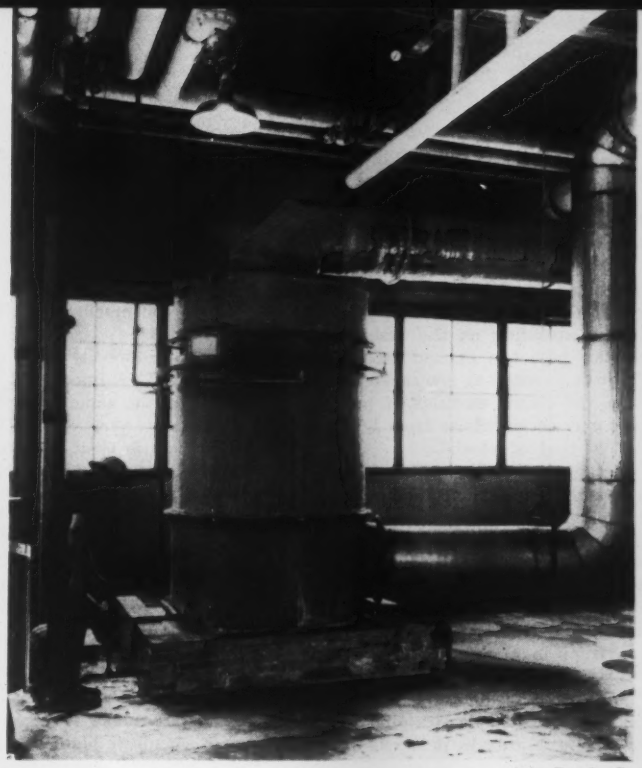
Glass-reinforced polyester laminates are being used in so many applications that it is impossible to cover them all. However, here are a few of the most significant:

Ducts—Glass-reinforced polyester laminates are achieving their greatest success in ducts and duct systems. Originally the laminates were used to patch metal ducts but they proved so successful in these applications that they began to be used for the complete system and have solved many severe corrosion problems. Materials engineers of American Cyanamid say, "This reinforced plastic has become the closest thing we have to a universal material of construction for duct systems."

Polyester ducts cost about $5.00 per sq ft as compared to $2.50 for painted (three coats, chemical resistant) mild steel ducts. However, the longer and maintenance-free life of the polyester ducts more than makes up for their relatively high initial cost.

Stacks—This is proving to be one of the most popular applications for glass-reinforced polyesters. One application is in the manufacture of alum where bauxite is digested in 78% sulfuric acid. Hot fumes and vapors proved very corrosive and troublesome. Installation of a 2-ft

Construction



Atlas Powder Co.

Scrubber *made of glass-reinforced bisphenol-A polyester is used in thorium extraction process to eliminate corrosive nitric acid fumes from plant exhaust ventilation. Plastic has successfully withstood fumes as well as dilute caustic soda used as a wash-down for over six years without requiring repair or maintenance.*

dia polyester stack solved the problem and set a pattern for future installations.

In another application sulfuric acid mist and moist sulfur dioxide had to be conducted to a high altitude to minimize air pollution. Many materials were considered, including mild steel, lead-clad steel and aluminum, but all had to be eliminated. A glass-reinforced furane stack was tried and this worked well for over three years before failing. Subsequent investigation showed that a glass-reinforced polyester pipe would be economically feasible, and it is now performing better than all other materials.

Dryer trays—Until several years ago the dryer trays used in making dyes, pigments and pharmaceuticals were made of enameled steel which was fragile, bulky and tended to rust. A switch to polyester trays proved so successful that they were subsequently used to replace those made of steel, stainless steel, monel and aluminum as well as enameled steel. In large quantities the plastics trays cost $4.35 apiece as compared to $4.86 for enameled trays. Aside from their lower cost the plastics trays have much longer life, and are more durable, lighter and easier to handle.

Other uses—Typical of other applications where glass-reinforced polyesters are proving out successfully are filter troughs, press plates and frames, liners for tote boxes and hoppers, and numerous types of storage tanks.

Both polyester and epoxy resins have been used with glass cloth as a repair material for chemical equipment for many years. In general, repairs using these materials should be considered as temporary until a more permanent repair or replacement can be made. One user warns (see *Szymanski*): "Maintenance personnel tend to place too much confidence in this type of repair, especially if they have worked on several jobs and are familiar with results. This can be dangerous if replacement or permanent repairs are not scheduled properly."

Rigid PVC is already an 'old' material

Compared to other plastics, rigid PVC (polyvinyl chloride) has enjoyed a relatively long life in the process industries. Some of the early European applications for PVC date back to 1937 and, although the material is relatively "old" as plastics go, it is still being used in large quantities.

Rigid PVC enjoys the same advantages as those outlined for reinforced plastics in the previous section. The material is currently being used in two principal types for the process industries. Type I is especially noted for its high chemical resistance, whereas Type II is usually being specified where good impact properties are needed. Type I is also noted for its excellent resistance to weathering over a period of many years. Both types are especially popular with users because of their ease of fabrication.

The principal uses for rigid PVC have been ductwork, fume hoods, stacks and vents. The material is also being used for small unsupported tanks and can be used for larger tanks if backed with a strong material such as steel. Because of its ease of fabrication PVC is easy to erect in the field and easy to modify if any structural alterations have to be made.

More and more users specify plastics pipe

Plastics piping received its first impetus during World War II when German engineers found that it made an excellent substitute in chemical plants for scarce metal pipe. Since this first application just two decades ago, the number of materials and applications has grown phenomenally, and estimates show that $100,000,000 worth of plastic pipe will be purchased in the United States in 1961 (large amounts are also used in Europe). Typical of current large-scale applications are the conveying of potable water, handling of salt

water and sour crude oil in the petroleum industry, containment of liquors in the paper industry, and acid pickling in metal fabrication.

Some current problems—Many pipe users (see *Sansone*) are disappointed by the thermal expansion of plastics pipe. Depending on the resin used, plastics pipe can expand from 4 to 17 times as much as low carbon steel. Also, the elastic modulus of plastics pipe may be anywhere from 1/100 to 1/1000 that of steel.

Another problem in using plastics pipe is that it usually has to be joined by solvent cementing to achieve its full strength. Threaded joints have several drawbacks: they require a derating of about 50% due to notch effect, bending stresses have a bad effect, and leaking can occur unless provision is made for thermal expansion.

How costs compare—The primary reason for using plastics pipe is that in some applications it is less expensive to use than equivalent metal pipe. As users well know, the cost of a piping system does not stop with the pipe itself but includes such associated items as joints, fittings, flanges and valves, and the availability of all components in compatible dimensions to provide maximum strength with minimum labor. Considering these factors, here is a brief rundown of how costs currently compare for 2-in. piping systems. (The author is indebted to Harvey E. Atkinson of Du Pont for the following information.)

Relative material cost—The cost of plastics pipe varies over a wide range from polyethylene (lowest) to TFE-lined steel (highest). Between these two extremes other materials increase in cost in this order: ABS, PVC, glass-reinforced epoxy, and saran-lined steel.

Labor cost—This is a very important factor in processing equipment. The cost of making a single joint is relatively low for materials such as polyethylene, ABS and PVC, and is relatively high for TFE-lined steel, glass-reinforced epoxy and saran-lined steel. Incidentally, manufacturers' recommendations for joining should be carefully followed. One materials engineer reports that as the result of his field foreman cutting down setting time to reduce costs, the joints subsequently failed and had to be completely redone.

Associated costs—Because of its lower strength, especially at higher temperatures, plastic pipe generally requires more support than metal pipe. This can be a considerable cost factor. For example, polyethylene requires continuous support at all temperatures, ABS and PVC have to be supported about every 8 ft at 75 F and continuously at 150 F, and glass-reinforced epoxy pipe requires support at intervals of 10 to 14 ft. Saran and TFE-lined steel pipe can be handled the same as Schedule 40 steel pipe.

PVC pipe is most versatile—PVC (Type I) pipe is one of the fastest growing piping materials for corrosion resistant applications. It is relatively inexpensive, resists a broad range of chemicals (except for some solvents) is available in a wide range of sizes, is easy to install, and is reliable. It is also noted for its flame resistance. Its temperature range is rather limited—0 to 150 F—but improvements in heat resistance are expected to make it acceptable for use in chemical plants at temperatures up to 200 to 215 F.

PVC pipe has enabled users to achieve some dramatic cost savings. In one example cited by Du Pont about $40,000 was saved in one process application by using 3000 ft of PVC pipe instead of aluminum, stainless steel and nickel alloy pipe. In another application, PVC replaced rubber-lined steel pipe for handling acid slurries at a saving of $20,000.

Glass-reinforced epoxy pipe shows promise—Glass-reinforced epoxy pipe is relatively new and experience with it to date is limited. However, because of its ability to be used at pressures up to 150 psi and temperatures up to 250 F, the material has a good potential and large-scale use can be expected. It is currently being used to handle phosphoric acid and in manufacturing dye and alum.

Polyethylene pipe limited to low pressures — Although popular for general applications, low density polyethylene is not widely used in the chemical process industries. It is inexpensive and flexible, and has excellent resistance to acidic materials and salt and fresh water. However, engineers report that it can only be used at relatively low pressures (50 to 75 psi) and temperatures (120 F), and that its resistance to hydrocarbons is poor. Also, it has high permeability to gases and is subject to cracking under some stress conditions. However, the newer high density polyethylene pipe is expected to open up new applications because of its greater rigidity and strength, and its ability to take temperatures to 150 F and pressures to 75 psi.

Saran giving ground to other materials—Solid saran (vinylidene chloride) pipe has given good performance in the past but some of the newer materials are giving it tough competition. It has fairly good corrosion resistance but is more expensive and has lower pressure and temperature limits than PVC. Also, its impact strength is relatively low and it has poor resistance to creep under load. However, the material performs well when used as a lining for steel pipe which provides the required support.

Chlorinated polyether pipe — Although relatively new, chlorinated polyether pipe has gained rapid acceptance in the chemical process industries and its future looks quite good. The material is available in solid piping or as a coating or lining. It is claimed to have the broadest chemical resistance of all thermoplastic piping materials. Its properties compare favorably with those of the fluorocarbons and it has the advantage of considerably lower cost. Another advantage is its high temperature limit—250 to 300 F.

Fluorocarbon pipe — Despite its relatively high cost, TFE fluorocarbon-lined steel pipe is ideal for severe applications where other plastics and metals fail. In fact because of its superior corrosion resistance it can even be used for equipment that normally requires a glass lining or special alloy steel. In one application cited by Du Pont, TFE pipe and fittings are being used at a cost savings of $60,000 a month over previously used materials. This includes maintenance savings and costs saved through a reduction in process shutdowns.

ABS pipe—Although ABS accounts for one-sixth of the piping used in all applications, comparatively little is being used in the process industries. Because of its great chemical resistance, PVC has cut into some of the applications formerly using ABS. However, there may be greater interest in ABS as a more complete line of fittings is developed and more data become available on high temperature grades. The material is relatively inexpensive and, because of its very good mechanical properties (it will take pressures of 100 to 250 psi at room temperature), it appears to have a definite place in future process applications.

What About

TITANIUM AND ZIRCONIUM?

They and other new materials are being accepted gradually to solve problems that conventional materials could not solve.

■ In addition to the metals discussed in the two previous articles, several other metals and refractories are becoming increasingly important for equipment where special properties are needed. At present these special materials are being used in relatively small quantities. However, users are finding that in certain applications they are cheaper in the long run than some of the more conventional materials.

Titanium offers efficiency plus corrosion resistance

The excellent corrosion resistance of titanium has been quickly recognized by materials engineers in the chemical process industries and it appears to have a definite place for certain applications. A large amount of data has been prepared on titanium's corrosion resistance. The data show that it can be used in contact with most salts; oxidizing acids such as nitric, chromic and aqua regia; dilute hydrochloric acid; most organic acids at room temperature; and dilute alkalis. These are general conclusions only and, because of the relative newness of the material, it is wise for users to conduct field tests under service conditions.

Aside from its corrosion resistance, titanium is gaining acceptance because it offers a high strength-to-weight ratio in structural applications. Users may object to the material's relatively high cost and difficulty of fabrication but despite these factors it can often do a job that no other material can do. A survey of recent applications shows that the metal is being used for a wide range of applications including:

- Centrifugal pumps handling chloride solutions.
- Tubular heat exchangers handling a variety of corrosive media, e.g., wet chlorine.
- Steaming chambers of textile bleaching ranges.
- Tops of high temperature reactors used in urea manufacture.
- Piping handling copper chloride.
- Steam legs in dye manufacture.
- Storage tanks (as a lining) for chemical synthesis.

This is just a sampling and it is noteworthy that many of the current applications involve large parts and large quantities of metal.

Zirconium has good resistance to some corrosive media

Zirconium is receiving a lot of attention in the chemical process industries because of its high resistance to certain chemicals. Like any other new material, it is being thoroughly evaluated and even though it is being used in relatively few applications at present it appears that the metal will play an important role (see "Zirconium Alloys: Corrosion Resistance and Strength Are Improving," M/DE, Feb '61, p 10).

Zirconium is particularly noted for its resistance to hydrochloric acid. It resists all concentrations at 100 F and its resistance to boiling 20% hydrochloric acid is quite good. It will also resist concentrations of sulfuric acid up to 80%; most concentrations of nitric acid at 212 F; as well as phosphoric, formic and oxalic acids. Some of the other common chemicals that it can handle are: hydrogen peroxide, sodium hydroxide, calcium chloride, and fused caustic soda.

Because of welding problems zirconium (like titanium) is reported to be difficult to join to common materials of construction such as carbon or stainless steels. Zirconium's corrosion resistance and fabrication properties are affected by impurities such as oxygen, nitrogen, hydrogen and carbon which are picked up during welding. However, this problem can be minimized by inert gas welding; flow purge welding and vacuum chamber welding also look quite promising.

The success of several recent applications testifies to zirconium's promising future. Among these applications are:

- Sulfuric acid concentration burner. Over 700 lb of zirconium are used in the burner and it successfully solved a catalyst poisoning problem (see photo).
- Heat exchanger that forms the calendria section of an evaporator for concentrating hydrogen peroxide.
- Dip tube that introduces chemicals into a reactor used in making an ester plasticizer. In this applica-

tion zirconium is in contact with a highly acidic mixture of caustic, sulfuric and phosphoric acids, alcohols and other corrosive materials.

▶ Pump impeller exposed to a complex corrosive solution of dilute hydrochloric acid, zirconyl chloride, thiocyanic acid and an abrasive polymer. The impeller has outlasted previously used materials by a wide margin.

Other materials

In addition to titanium and zirconium some of the other newer materials which are receiving close attention and which show potential for greater use for chemical process industry applications are:

Platinum group metals—As noted recently in M/DE (see "Where to Use Platinum Group Metals," Feb '60, p 126), the use of platinum and platinum group metals has more than doubled since World War II. The increasing popularity of these metals is due to their ability to outperform other materials and, despite their high initial cost, their long-run economy over the life of a product. Typical of the successful uses for platinum are: crucibles, spinnerettes for making textile fibers, equipment for making molten glass, and glass-to-metal seals.

Tantalum—Tantalum is best known for its resistance to practically all acids at room temperature; in many respects its resistance properties are quite similar to those of glass. Like platinum, the metal is relatively costly; nevertheless, users are finding that it is the only suitable metal for specialized applications. For example, the metal is being used successfully as a liner in a dissolver where it is exposed to both boiling sulfuric acid and mercury at 400 F. Corrosion of the liner by mercury is very low and its corrosion rate in boiling 10.8 molar sulfuric acid is acceptably low—about ½ mil per year.

Refractory materials—Refractory materials such as silicon carbide are proving valuable as substitutes for metals in applications calling for high corrosion resistance plus resistance to abrasion, erosion and heat.

Silicon carbide can be used up to 4000 F, has a thermal conductivity more than twice that of stainless steel, and is one of the most oxidation resistant materials known. It has high resistance to mineral acids at all concentrations and temperatures and excellent resistance to corrosion by gases at high temperatures. With a Knoop hardness of 2740, it is exceptionally wear resistant, and is claimed to outlast conventional wear resistant materials by 3 to 50 times, depending on the application.

Silicon carbide's excellent combination of properties has led to a variety of process equipment uses, such as spray nozzle inserts for abrasive slurries, orifice plates for acid service, and discharge cones of wet cyclone type equipment that handles ores, pulp fibers, and other abrasive media. A novel application is its use as a suction box cover on Fourdrinier paper machines; life of the Fourdrinier wire cloth can be nearly doubled. Under active development are thread guides for synthetic fibers, heat exchangers for severely corrosive conditions, and components for mechanical seals.

Molybdenum—Molybdenum is attracting interest in the process industries because of its good resistance to many acid media and liquid metals. Originally it was used to patch other materials that failed, but as engineers become more confident with the material they are using it increasingly for equipment such as valves, heat exchangers, reboilers, steam lancers, tank liners, and guides for making synthetic fibers.

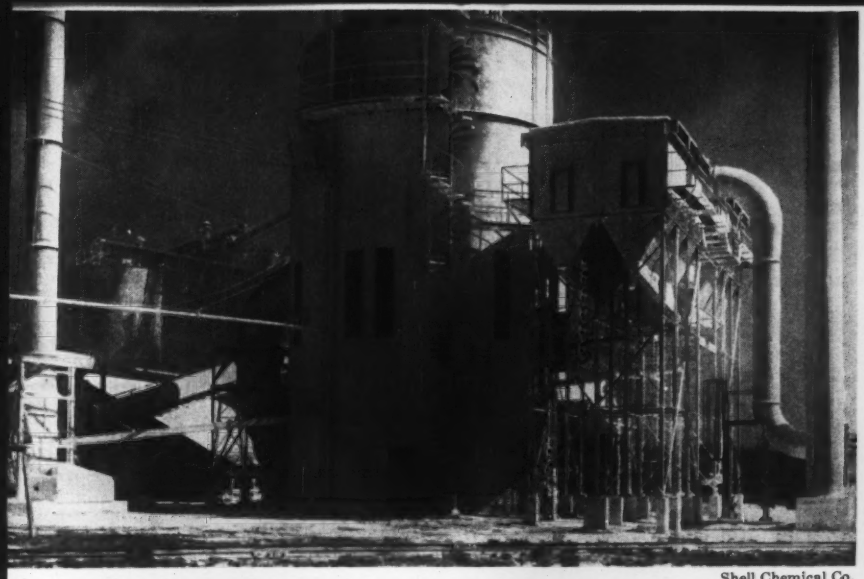
Columbium—Columbium has good corrosion resistance but it is not nearly as good in this respect as tantalum. It resists most organic and mineral acids at ordinary temperatures. However, it is not very resistant to alkalis and its resistance to mineral acids drops off with increasing temperature. Hot concentrated hydrochloric and sulfuric acids will cause some attack. Tantalum is preferred over columbium for process equipment because of its greater resistance to mineral acids. However, if the cost of columium drops to that of tantalum it could become competitive for some applications.

Carbon and graphite—Carbon and graphite have a long history of successful use in the process industries. Because of graphite's combination of high thermal conductivity and corrosion resistance, users are continuing to find that it makes an excellent material of construction for heat exchangers. Some very interesting designs have been recently constructed, many of which are quite large.

Other recent developments worth noting are carbon rupture disks, carbon ejectors, graphite mixing nozzles, and graphite pump parts. The carbon rupture disks are proving to be competitive with stainless steel because of their corrosion resistance and low cost. And the graphite mixing nozzles are proving useful in a sulfuric acid dilution plant because, in addition to handling corrosives, their excellent thermal properties permit high operating temperatures and heat transfer rates.

Pfaudler Permutit, Inc.

Heat exchanger *is largely made of zirconium to solve corrosion problem in hydrogen peroxide concentration.*



Steel dust collector *flues and stacks protected with epoxy coating are still in excellent condition after two years of operation. Several tons of acid-containing water are evaporated in unit every hour at 320 F.*

Shell Chemical Co.

New Developments in

PROTECTIVE COATINGS AND LINERS

■ Because of the range of media and atmospheres that is encountered, the chemical process industries need a wide variety of coatings—most of them organic. This need stems from the fact that:

- More corrosive chemicals are being processed and manufactured today.
- Industrial atmospheres are worsening.
- Base metals are getting more expensive and must be protected to avoid costly maintenance and replacement costs.

Because of the great competition among coating suppliers (estimates show that over 3600 companies are engaged in manufacturing paints and coatings for consumer and industrial use) it is extremely difficult for the materials specialist to keep up with new coating announcements and literature. And coating selection is made even more difficult because, due to competition, many suppliers are forced to put a new coating on the market before it is fully developed and field tested.

In light of the multiplicity of new materials now being made available, what new developments and critical problems bear watching? Here is a rundown on important trends:

Hot spray vinyls give high solids content

Hot spray vinyl coatings are gaining an important place in the chemical process industries because of their high solids content and their ability to be deposited in heavy thicknesses. Cold spray vinyls are fine for certain applications, notably for water resistance, but they must be cut back with a high percentage of thinners which makes for relatively thin films and increases chances of pinholing. Pinholing can, of course, be minimized by multiple coating but this raises costs.

Use of the hot spray technique, on the other hand, permits a cutback in solvent content and a big increase in vinyl content. Incidentally, you should keep a close eye on the formulation purchased for hot spray application to make sure you get a high solids content. One materials engineer reports that some formulators have attempted to pass off a cold spray vinyl formulation as a hot spray formulation.

Hot spray vinyls, like all other coatings used on processing equipment, must be applied over carefully prepared surfaces in order to perform properly. Surface preparation is a big problem in the process industries; records show that it can amount to one-third of the total coating cost. In general, surfaces should be prepared in accordance with "Steel Structures Painting Council Specification No. 7, Brush-Off Blast Cleaning." This procedure relies on the impact of abrasives to rapidly remove loose mill scale, rust and loose paint. Sandblasting is proving out well, and one materials engineer reports that it is actually cheaper than wire brushing in terms of both reduced labor cost and longer coating life.

Some typical oil refinery applications for the hot spray vinyls are waste water separators and cooling tower piping. In the case of the separators which are exposed to water, waste oil and heat, all previous paint systems failed within months. The hot spray vinyl system, however, is in excellent condition after 1½ years. In the case of the cooling tower piping, the hot spray vinyl looks as though it will provide better service than a ⅛-in. thick asphalt mastic previously used.

Catalyst-cured epoxies resist most chemicals

Despite their relative newness, catalyst-cured epoxy coatings have gained rapid acceptance. Users are pleased with the fact that they resist most chemicals, stand up well outdoors, and have moderately chalking and self-cleaning properties. Another important advantage is that their temperature limit is higher than that of almost any other maintenance paints—about 300 F.

The catalyst-cured coatings also have good adhesion. In this connection engineers point out that it is very important to follow manufacturers' application instructions. Epoxies cure by polymerization and

if excess time is allowed between coats the first coat may become insoluble and prevent adhesion of the second coat.

Oil refinery materials engineers report excellent results with a relatively new class of coatings based on catalyst-cured epoxy-modified phenolics. The ratio of epoxy to phenolic depends on the application. What is interesting about these coatings is that, unlike the straight phenolics, they have good resistance to alkalis as well as resistance to acids. And, unlike the vinyls, they resist temperatures above 150 F immersed, and far above 180 F dry. Thus, the coatings appear to be well suited for protecting oil refinery equipment, and they have already successfully proved out in such applications as propane drum linings, surfaces immersed in water and steam condensate, interiors of light oil tanks, and cooling tower fan assemblies.

At the present time it is a bit too early to say how the 100% solids, solvent-free epoxy coatings will fare. The coatings are notable for their high build-up (up to 10 mils per coat) and freedom from fire hazard. However, some engineers still feel that they are too expensive for maintenance use, mainly because of the special application equipment required. However, this problem may have been licked with the recent development of equipment that is much easier to use.

High-build alkyds show promise

Alkyd paints are widely used today for mild indoor and outdoor service. Ordinarily the dry film thickness of alkyds has been about 1.5 mils per coat. However, recent work in the application of high-build alkyds is showing promise and may extend the usefulness of the coatings. When carefully applied in multiple passes, one 4-mil coat of a high-build type coating has proved to be as satisfactory as two coats of a conventional alkyd. A thickness greater than 4 mils can produce "mud cracking" after a year of exposure. However, satisfactory one-coat application of high-build alkyd red lead primers has been obtained on vertical surfaces with dry films as thick as 6 to 8 mils.

Elastomeric linings gaining in acceptance

Natural rubber and synthetic elastomer linings have gained rapid acceptance in the chemical process industries because of their resistance to many chemicals, their abrasion resistance and their low cost. Here is a summary of current trends:

Natural rubber is presently used in 70% of lining applications and will continue to be popular because it can be formulated with a wide range of properties.

Butyl rubber is not extensively used now, but it could well develop into large volume applications in the future because of its high chemical resistance.

Neoprene and *nitrile rubber*, more costly than natural rubber, will probably be used only in applications where other linings are unsuitable.

Chlorosulfonated polyethylene (Hypalon) is catching on slowly but surely as a lining material and appears to have a good future, particularly where resistance to strong oxidizing chemicals is needed. It has been successfully used recently for handling strong caustics and for containing spent sulfuric acid from refinery operations.

Fluorocarbon rubber linings have not been in use long enough for significant corrosion data to accumulate. However, indications are that because of their good combination of high resistance to heat and chemicals they will gain a firm place for lining applications.

Use of nickel coatings and linings is growing

Nickel and nickel alloys have long been recognized as one of our most corrosion resistant group of materials. But because of their relatively high cost in solid shapes, designers have not always been able to use them in as many applications as they would have liked. However, recent developments in the application of nickel to less costly and high strength materials show promise.

Electroless nickel—Because of their success on tank interiors, designers are gradually recognizing the potential of electroless nickel coatings (sometimes called chemical nickel coatings or nickel-phosphorus coatings because of their 8 to 10% phosphorus content) for chemical process equipment.

Electroless coatings can be used on tank car interiors (at present this is still the largest volume application) to provide protection against such materials as caustic soda, ethylene oxide, tetraethyl lead, tall oil, fatty acids and glucose. The coatings are also proving useful in preventing iron pick-up or contamination and currently are being used (in 3-mil thickness) for this purpose on large carbon steel rotary dryers and rotary reactors for processing foodstuff additives. They are also proving useful for petroleum processing.

Developers of electroless coatings claim that they offer corrosion resistance equal or superior to that provided by wrought or electrolytic nickel and that they can often substitute for solid stainless steel parts or expensive clad alloys. Savings of about 75% are claimed for one electroless nickel-coated carbon steel pump casting. However, such savings are not always the case. Some engineers still feel that the coatings are too expensive and that it is cheaper in some cases to use a stainless steel body. They also point out that shop limitations make it difficult to handle large parts.

In addition to their chemical resistance, electroless nickel coatings can be heat treated to provide good toughness and high hardness—up to Rockwell C54. It is claimed that in hardness and wear resistance the coatings compare well with chromium electroplates, and for this reason are well suited for rotating and reciprocating equipment and where abrasives are encountered.

Nickel electroplates — Because of the high cost of piping made completely of premium materials, there has been a great deal of development lately in composite piping consisting of a corrosion resistant interior layer and an outer layer of a low cost, high strength material such as carbon steel. One of the most promising of the new composites is electroplated nickel pipe. Because of the success of this pipe in nuclear applications it is expected to become popular for process applications. Actually, the nickel layer can be built up quite heavily but in order to keep the material competitive its thickness is usually held below the thickness of nickel used in nickel clad pipe.

Nickel alloy pipe linings—Fabrication breakthroughs are now making a greater number of pipe linings available to the designer. Fabricators have found that conventional thin-wall tubing of such corrosion resistant materials as nickel, monel and 70-30 cupro nickel can be hydraulically expanded inside thicker-walled piping made of nonpremium materials. Another important development now in the works is the use of thin-wall nickel strubing (flat pipe that has been expanded) inside a heavier-walled pipe.

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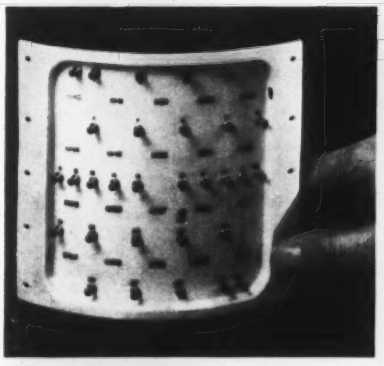
SILICONE NEWS

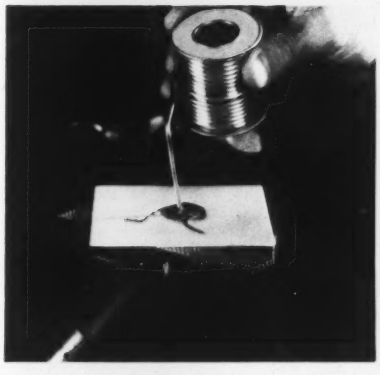
for design and development engineers • No. 80

When Going Is Rough

LOX cold . . . high Mach heat . . . corona . . . ozone . . . launching and sonic shock—more and more environmental challenges are being met by Dow Corning Silicones.

Take silicone-glass laminates made with Dow Corning resins, as examples. Silicone-glass laminates have good mechanical strength, low loss factor, low moisture absorption, excellent resistance to arcing, corona, corrosive atmospheres, fungus and contaminants. What's even more important, they retain these properties despite elevated temperatures, storage, environmental aging, rapidly changing ambients, vibration and shock. Heat resistance of silicone-glass laminates is exceptional . . . up to 250 C continuous for years . . . much higher for short time periods.





Lear, Inc., of Grand Rapids, Michigan mounts the mica capacitors of their Model 2013J Stable Platform for missile guidance systems on this formed silicone-glass laminate terminal board, made by Silicone Insulation, Inc., Bronx, N. Y. *(Cont. Pg. 2)*

ALWAYS READY FOR USE

Cabin decompression is a possibility (even though remote) in a jetliner flying at 30,000 feet or higher. To meet this eventuality, high flying commercial jets now provide the ultimate in passenger safety with automatic positioning oxygen masks made of Silastic®, the Dow Corning silicone rubber.

If decompression should occur, these silicone rubber masks will immediately pop out of their storage compartments, ready for use by seat occupants. Why are these masks made of Silastic?

Here are the requirements as enumerated by the manufacturer, ARO Equipment of California, Los Angeles. Although it's stored crushed in a small area, the mask must return to its original shape without damage. It must be odorless; nontoxic in direct contact with skin; easy to clean and sterilize; flexible to −65 F; withstand a test of 72 hours at 160 F temperature without visible damage; and, be resistant to the cracking and checking effects of

oxygen and ozone. Futhermore, the masks must retain these properties and remain reliable for an "in service" life of more than three years! Silastic meets *all* of these operating and storage requirements!

Over 100 rubber companies now manufacture parts from Silastic. For a list of these suppliers, circle . . . . **No. 241**

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

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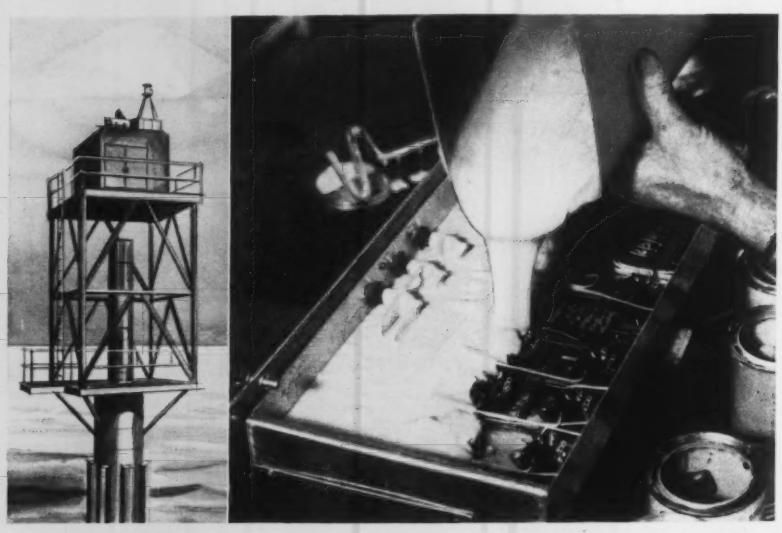

TO REDUCE HAZARDS

Development of offshore oil fields presents problems not generally encountered ashore. For example, whoever worried about the shipping hazards of drilling and pumping rigs? This was the problem that led Automatic Power Inc. of Houston, Texas to design their DA-20 Dies-L-Air offshore warning systems.

An essential element to Automatic Power's new warning signal is the DAE 12 volt d-c controller that monitors operation of the entire warning signal system including the diesel engine, air system, control circuitry, and horns. More dependable than a human attendant, the controller immediately detects any irregularity of operation of the Dies-L-Air and automatically starts the standby system.

Obviously, reliability is essential. And that's why engineers at Automatic Power selected Silastic RTV to embed and protect all tube sockets, connections, wiring and other components in the controller chassis. Silastic RTV is the fluid silicone rubber that cures without heat. Being resistant to heat, ozone, corona, weathering, and oxidation, it keeps the controller operable in spite of corrosive salt water spray and wind-driven rain. Extreme temperatures have no effect on this silicone rubber—it remains serviceable from —70 to 500 F! Silastic RTV pours easily as a liquid and cures to a firm, rubbery mass with good dielectric and physical properties.

To obtain more detailed information about Silastic RTV, circle . . . . *No. 242*

SILICONE-GLASS *(Cont.)*

Tolerance requirements, plus assembler variations dictated a material that could be formed . . . would withstand soldering temperatures . . . would hold its form despite environmental extremes. Environmental conditions are: —40 to 160 F; shocks of 30 G's for about 11 milliseconds each; complex wave vibration for 20 minutes in each plane as follows—30-100 cps: 0.46 g^2/cps and 100-2000 cps: 0.015 g^2/cps.

Glass laminates made with Dow Corning silicone resins are available from leading laminators. For further information and list of laminators, circle . . . *No. 243*

new literature and technical data on silicones

Motor Stability with Silicones—Complete data on an entirely new silicone impregnating varnish is available in this 4-page bulletin. Dow Corning 981 Varnish provides an exceptionally high order of heat stability and is applicable in Class A, B, F, or H systems. Graphs show specific gravity-temperature and viscosity-temperature curves. An entire page is devoted to the typical properties you can expect from cured 981 Varnish films. See if you'll want to specify Dow Corning 981 Varnish by writing for . . . . . *No. 244*

Greater Stability Plus—Silicone diffusion pump fluids make the operation of pumps more efficient over longer periods of time and under more adverse conditions. After as many as 1100 cycles of heating to operating temperature and partial cooling, with exposure to air during each cycle, silicone fluids do not decompose into gums or tars. Rapid recovery, quick pump-down, inertness, fine vacua and economy are other advantages of using heat-stable Dow Corning diffusion pump fluid. *No. 245*

Compiled for Advanced Research and Development Engineers, an eight-page reference provides a convenient guide to selecting the most suitable silicone fluid medium when designing damping, springing, coupling and related mechanical devices. Includes tables, graphs and detailed information about properties that enable Dow Corning silicone fluids to increase efficiency of existing designs and make possible new design changes. *No. 246*

Silicones in Industrial Finishes is the title of an article pointing up the advantages of silicone protective coatings. Excellent resistance to corrosion and heat have put these general weathering and low temperature silicone-based paints in great industrial demand for everything from smoke stacks and mufflers, to space heaters, refrigeration equipment, and open plant piping. This is an important reference for any designer interested in durable finishes for plant, equipment or end products. *No. 247*

Dow Corning Corporation, Dept. 5314, Midland, Michigan

Please send me: 241 242 243 244 245 246 247

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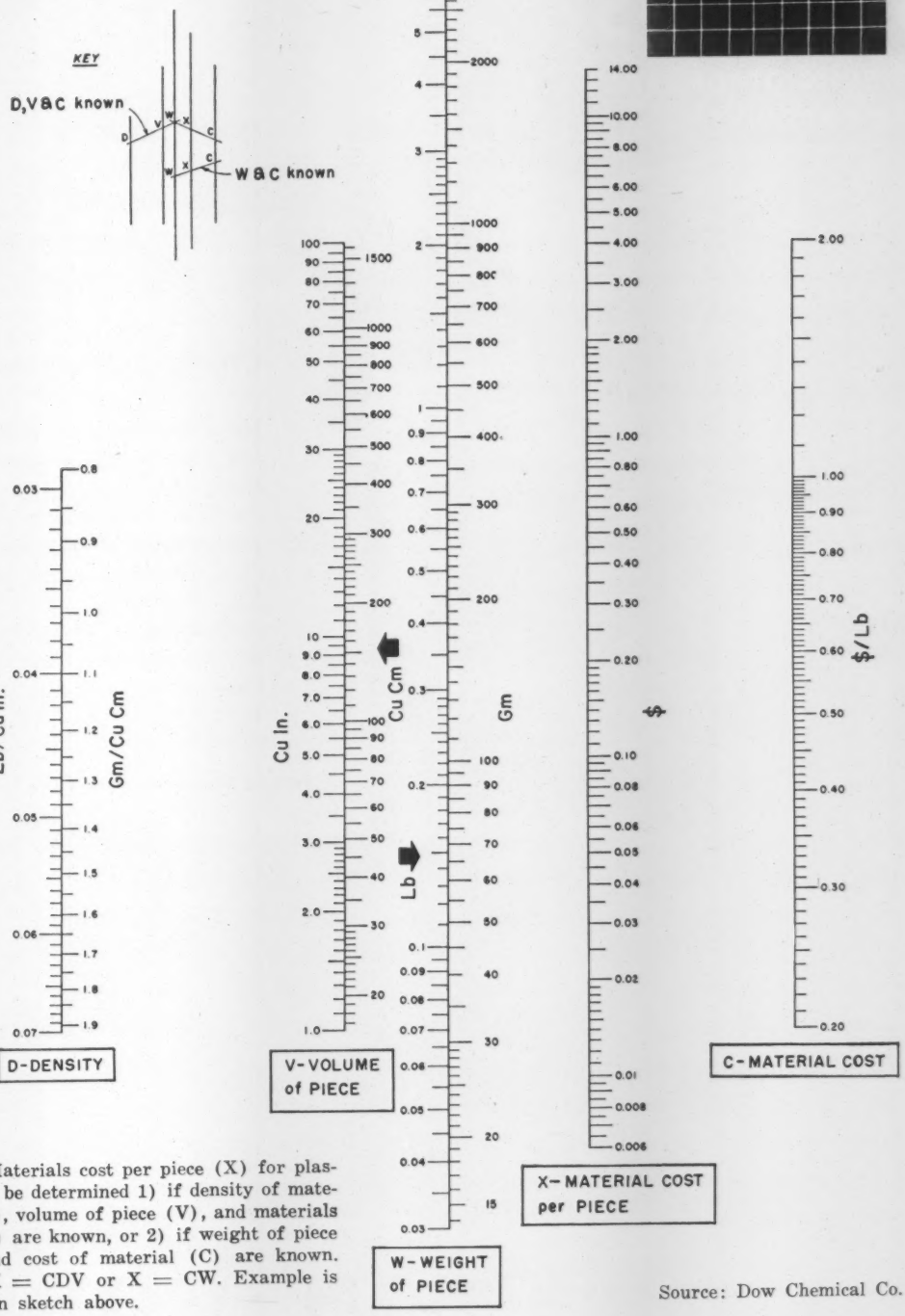
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE IN COUPON ABOVE, OR REFERENCE NUMBER ON READER SERVICE CARD

Nomograph: Materials Cost Per Piece for Plastics Parts

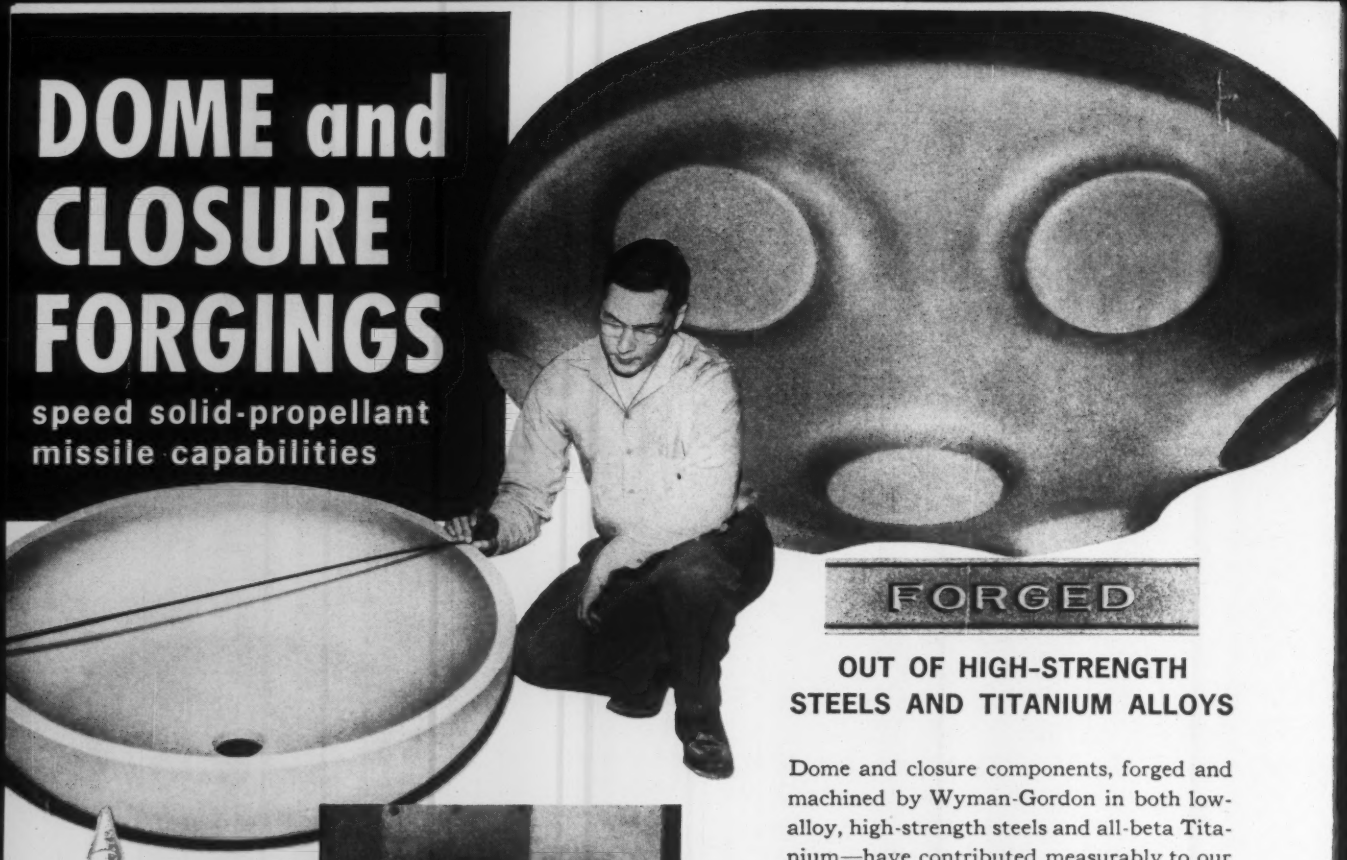


Note: Materials cost per piece (X) for plastics can be determined 1) if density of material (D), volume of piece (V), and materials cost (C) are known, or 2) if weight of piece (W) and cost of material (C) are known. Thus, X = CDV or X = CW. Example is shown in sketch above.

Source: Dow Chemical Co.

DOME and CLOSURE FORGINGS

speed solid-propellant missile capabilities

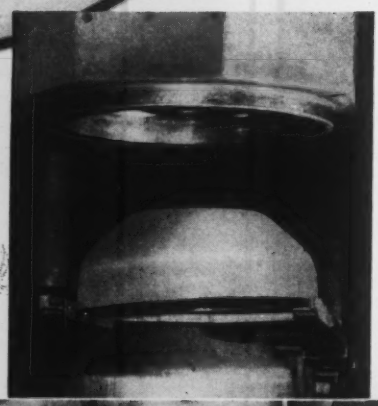


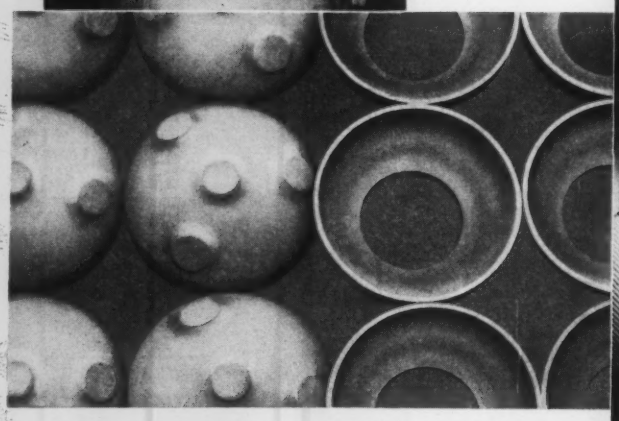
FORGED

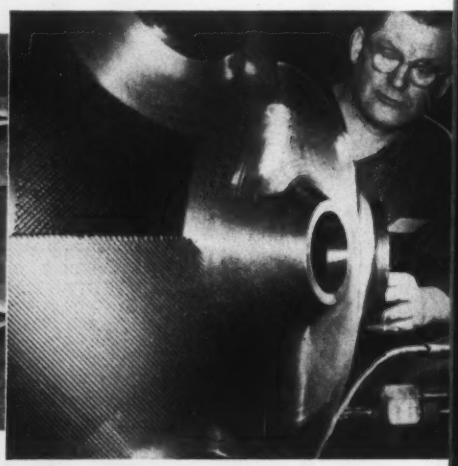
OUT OF HIGH-STRENGTH STEELS AND TITANIUM ALLOYS

Dome and closure components, forged and machined by Wyman-Gordon in both low-alloy, high-strength steels and all-beta Titanium—have contributed measurably to our present status in solid-fuel missile development. Research is continuing for the purpose of adapting new materials to these applications. Wyman-Gordon engineer-metallurgists are available to counsel on all phases of forging such critical-service parts. Their assistance can help extend ultimate-strength limits of your space designs.

For more information, turn to Reader Service card, circle No. 443







EST. 1883

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

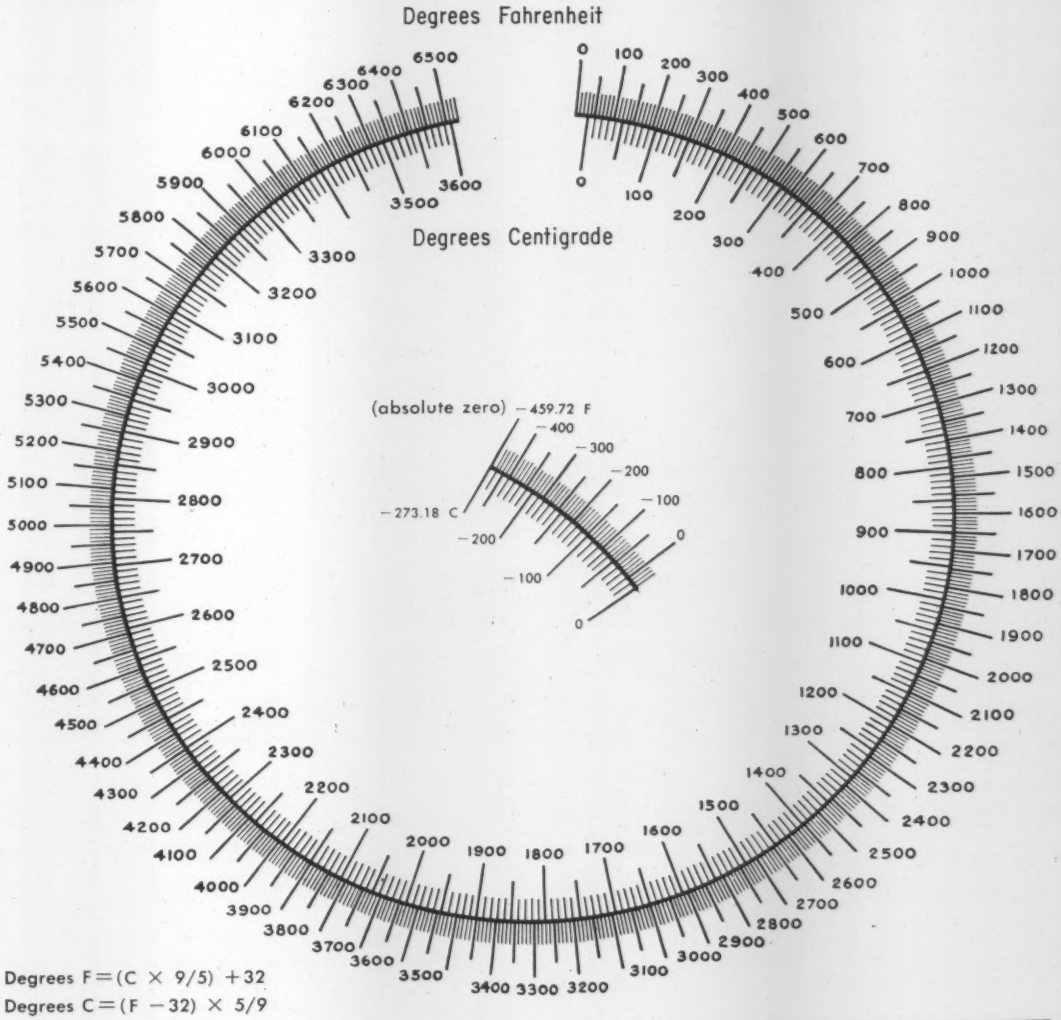
HARVEY ILLINOIS WORCESTER MASSACHUSETTS DETROIT MICHIGAN

GRAFTON MASSACHUSETTS LOS ANGELES CALIFORNIA PALO ALTO CALIFORNIA

FILE FACTS

If this page looks familiar, it may be because you saw it in our November issue (p 157). Unfortunately the slip of a draftsman's pen (perhaps years ago for all we know) went unnoticed, and the low temperature end of the scale shown in the center was inaccurate. Thanks to a few sharp-eyed readers we now publish the corrected version.

Quick Temperature Conversion Scale (Corrected)



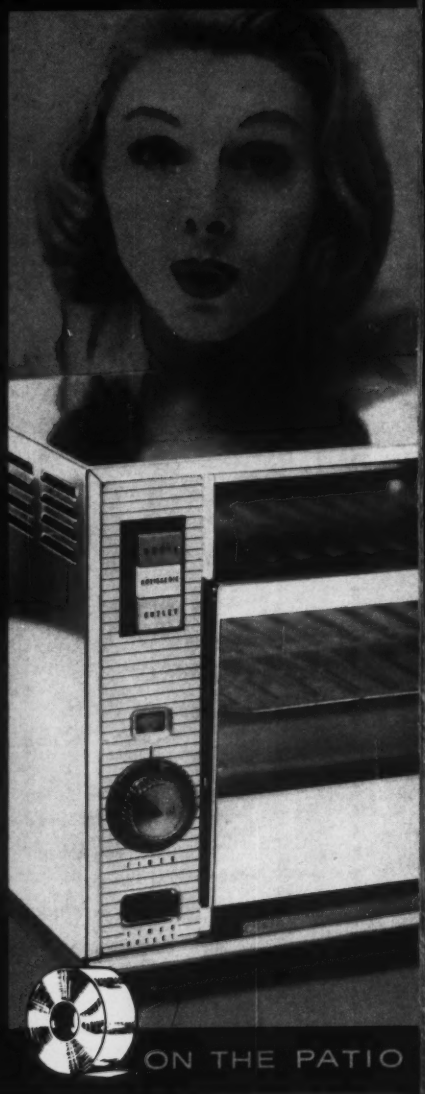
Degrees F = (C × 9/5) + 32
Degrees C = (F − 32) × 5/9

Courtesy: Fansteel Metallurgical Corp.

NICKELOID IS EVERYWHERE

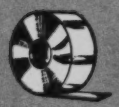
ON THE MANTLE

ON CARPETING



ON THE PATIO

These eye-catching products use functionally a basic Nickeloid Metal. The finish of Chromium, Nickel, Brass or Copper is electroplated to a base metal, usually Steel (but often Zinc, Brass or Copper).



Mostly, Nickeloid Metals are supplied in continuous coils in widths up to 24" for modern, low cost fabrication. They're also available in sheets and strips. Optional: bright or satin finishes, plating one or both sides, a galaxy of stunning patterns and crimps.

Quality plating produces metals so durable they can be fabricated, even quite severely drawn or bent. Rejects minimized. For severe stamping, we offer Mar-Not protective coating that is easily peeled off after its job is done.

Which is your preference in modern metals — the clean, flint-hard gleam of Chromium, the warmth of Copper, or the rich radiance of polished Brass? No need to answer now, but consider the galaxy of wonderful products you find everywhere today that employ one of the Nickeloid Metals. These durable, lustrous finishes are not mere lily-gilding. In most instances they are designed INTO the product . . . functionally. We make a raw material that has been given these quality finishes the *automated* way . . . in giant coils in block-long mills. Nickeloid finishes are electroplated to the base metal *before fabrication*, a process as fundamental we believe as the coating of printing papers in rolls *before they are printed*. Three out of five costly manufacturing steps are by-passed. Write for our free Introductory Kit, which includes metal samples — learn the complete story.

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PRICES & SUPPLY

...AT A GLANCE

Production and consumption of engineering materials remained at high levels during 1960, according to year-end estimates now being released. In metals . . .

Aluminum production was up 3% last year to over 2 million short tons. Titanium mill product shipments totaled 10 million pounds, a 50% increase over the previous year. Steel production amounted to about 100 million net tons of raw steel, 6% above 1959 and 15% below the 1955 peak of 117 million tons. Consumption of nickel exceeded 500 million pounds, a 15% increase over 1959. Primary magnesium production was 39,600 tons, 28% above the 31,000 tons produced in 1959. And in nonmetallics . . .

Plastics production was up 5% in 1960 to 6,158,000,000 lb. Last year polystyrene passed the billion pound mark, joining polyethylene and vinyl which reached this position in 1959. Synthetic rubber production reached 1,450,000 long tons, compared to 1,380,000 long tons in 1959.

A 1¢-per-lb cut in the price of copper to 29¢ has been announced by Kennecott Copper Corp. Other producers are expected to follow with similar price cuts.

More polyvinyl fluoride film will be available when Du Pont's new plant in Tonawanda, N. Y. begins production in mid-1962. Production figures have not been disclosed. The plastics film, called Teslar, is currently being produced in limited quantities at Du Pont's Yerkes Research Laboratory in Buffalo, N. Y.

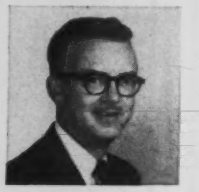
A price increase for general purpose polystyrene has been announced by Dow Chemical Co. New truckload price is 19¢ per lb, a ¾¢-per-lb increase. Recently, price of general purpose polystyrene was reduced to 18¼¢ per lb by Dow and other producers (M/DE, Jan '61, p 103).

Columbium supply is adequate at present and can be greatly increased in the next few years if demand warrants it, says C. T. Sims of General Electric Co. According to Sims, 10,000 tons of columbium mill products can be produced annually in the next two to five years if columbium-bearing ores are exploited more completely, controlled atmosphere rolling mills are developed, and alloy sheet rolling improves. He says columbium mill products will sell for $5 to $10 per lb when annual production reaches 10,000 tons, making columbium the most inexpensive refractory metal available.

Price reductions on Teflon fluorocarbon resins have been announced by Du Pont. New prices for TFE resin in truckload lots are: Teflon 1 and 5 molding powders, $3.25 per lb; Teflon 7, $3.75; Teflon 30 and 30B dispersions, $4.30; and Teflon 6 and 6C extrusion compositions, $5.05. Prices of Teflon FEP resin and film have also been reduced. New price for FEP resin is $9.60 per lb in truckload lots; film prices range from $13 per lb for 2-mil thick film to $18 per lb for ½-mil thick film.

A complete roundup of current prices will appear in the March issue.

For more information, circle No. 335



Technical-ities

By Fred E. Graves

Fastening of rigid joints

Theoretically, there's no such thing as a rigid joint. There's always some elasticity of the fastened metals. For practical purposes, you can consider a joint rigid when the bearing areas of the metal-to-metal fastened members will not crush or yield before the full load-carrying capacity of screw or bolt is developed.

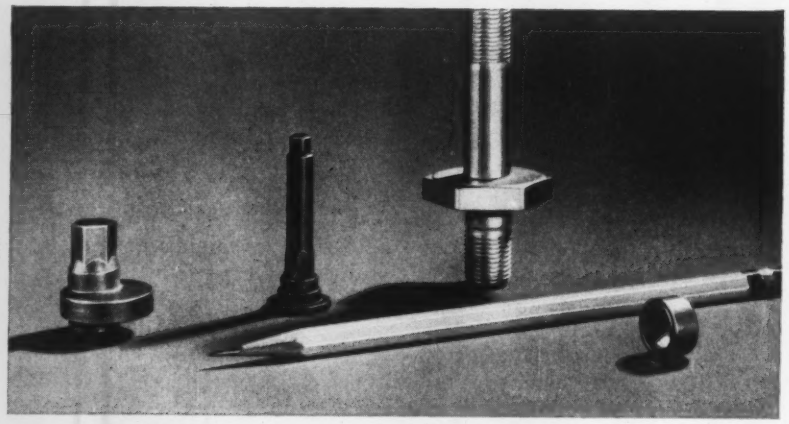
PRODUCT BENEFITS

Rigid joints afford a definite product advantage. They can take high strength hex screws or bolts tightened up to fastener yield strength or beyond. Under such tension, fasteners have demonstrated that they'll stay tight despite vibration. They are resistant to fatigue from the constant load reversals. High Strength Hex Screws cut costs and speed assembly too, since you can reduce *size* of the fasteners or their *number*, while actually improving joint strength.

INSTALLATION HINTS

When you're connecting steel members of fairly heavy section, you've no problem getting a rigid joint. Just clamp them to the full fastener capacity. Thin sections can be reinforced and similarly fastened. And in joining milder steels or softer metals, use of a plate washer will distribute bolt load, prevent crushing and give the desired effect of rigidity.

When to plan on cold-formed special parts



COLD forming is basically a large volume, low cost method of obtaining component parts.

Above you see four specific *types* of parts that benefit from this production method:

ECCENTRIC SHAPES

When the piece is radically eccentric, and is further complicated by having several different diameters, cold forming may prove the only way to produce the piece at a reasonable cost. Machining it from a bar would be prohibitive in scrap loss and machining time.

MULTI-DIMENSIONAL DESIGNS

When pieces are complicated, cold formers can often shape item in two or three blows. Tolerances are close enough for practical uses, and no further finishing need be done except for some secondary machining or drilling if required by the design.

ONE-PIECE PARTS

When simple, small two- or three-piece assemblies can be replaced with unit parts, the production man saves assembly time as well as material costs; the designer gets a stronger part. For example: stud with integral hex, square, or round upset anywhere in-between. Note the extreme upset shown.

PARTS WITH HOLES

Nut formers produce parts by the thousands per hour like the one shown above. Holes are punched out, leaving smooth, clean, work-hardened and strengthened surfaces.

Bear in mind that unlike machining, cold forming cuts none of the metal's flow lines. So parts are tougher and more fatigue-resistant, as well as more economical.

As a fastener manufacturer, RB&W makes an ideal and experienced source of supply for such items. The same facilities used for standard screws and nuts can also pound out the required specials. Refer your problem to Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. **Sales office and warehouse at:** San Francisco, Calif. **Additional sales offices at:** Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas.

For more information, turn to Reader Service card, circle No. 421

(cont'd from p 110)

Pull Tabs for Drawn Aluminum Cans

Drawn aluminum cans with no side and bottom seams and a new easy-opening top are now being produced on a fully mechanized line at Central States Can Corp.'s plant in Massillon, Ohio. (For an earlier review of the potentials of aluminum cans see M/DE, Jan '58, p 10.)

The new opening method uses a pull tab to remove the lower of two lid seams. The tear strip does not leave any sharp edges on the can or lid when it is removed. In addition, the lid itself has a deep, countersunk shape so that it fits snugly when replaced.

There are several advantages to the drawn cans according to company spokesmen. Empty cans weigh only one-third as much as similar tinplate containers. Because aluminum is noncorrosive, the cans may be safely stored for indefinite periods. The dangers of side and bottom seam leakage are eliminated in drawn cans. Finally, the recessed lid enables the cans to be easily and securely stacked.

Four steps in production

The production method developed by Central States in conjunction with E. W. Bliss Co., manufacturers of the machinery, and Kaiser Aluminum & Chemical Corp. consists of four basic steps.

1. Coated aluminum coil is blanked and the initial draw (up to one-half the diameter of the finished can) is made. The draw for 3 7/16-in. by 1 13/16-in. cans is completed in this stage.

2. For cans of greater height, the second draw is completed on an automatic re-draw press.

3. Trimming and flanging operations complete the cans before they are conveyed to the packing area.

4. After the cans are filled, the covers are closed by conventional double seaming.

The entire can line is mechanized with overhead conveyors carrying materials through all stages. One operator and a packer comprise the crew for the operation which produces from 200 to 240 cans per min.

***Pull tab removes lid** from an aluminum can without leaving sharp edges. The replaced lid will fit tightly.*

Precise Die Extrudes Ceramic Cartridges

Asymetrical X-shaped ceramic cartridges for stereo phonographs are being successfully extruded through a very precise die.

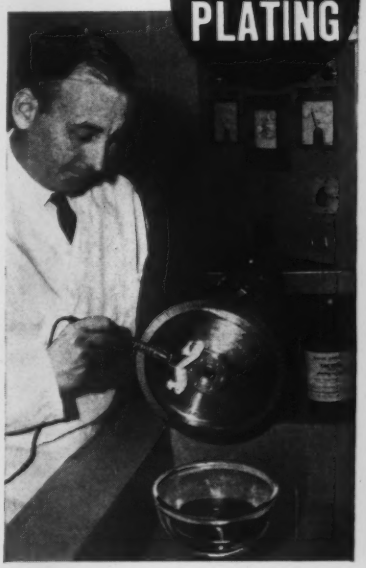
The die, made by F. J. Stokes Corp., Philadelphia, extrudes a shape whose four arms are only 0.031 in. long and 0.0155 in. wide. Tolerances on the die have to be held as close as +0.0000 in. and −0.0005 in. and the angles between the arms held to 1 deg.

Because of the unusual cruciform shape and the precise dimensions required, the die could not be made in one piece. Rather, it was made in four segments: two perfectly matched pairs of different-size pieces which were fitted together within a circular holder. Matching these four segments to within 0.0005 in. was one of the closest tolerances ever encountered in die work, according to W. C. Bobbitt, manager of F. J. Stokes' Punch & Die Div.

Special alloy used

For greater wear resistance

MIS-MACHINED PARTS SALVAGED WITH DALIC PLATING



DALIC Nickel Plating the out-of-tolerance portion of superalloy turbine wheel to specification size.

Dalic Plating has become a recognized manufacturing method for rebuilding undersized sections of products to meet specifications. Many of America's largest companies are using Dalic Plating to restore mismachined products to their full value.

You can build-up exact areas on components including flat surfaces, inside and outside diameters, grooves, etc. Plating thickness can be controlled accurately.

Quick Low Cost Salvage

Electroplating is done without immersion tanks, and at deposition rates 30 to 60 times faster than conventional plating. Selected areas are plated rapidly with little masking and no disassembly of components.

Deposits have excellent quality and adhesion.

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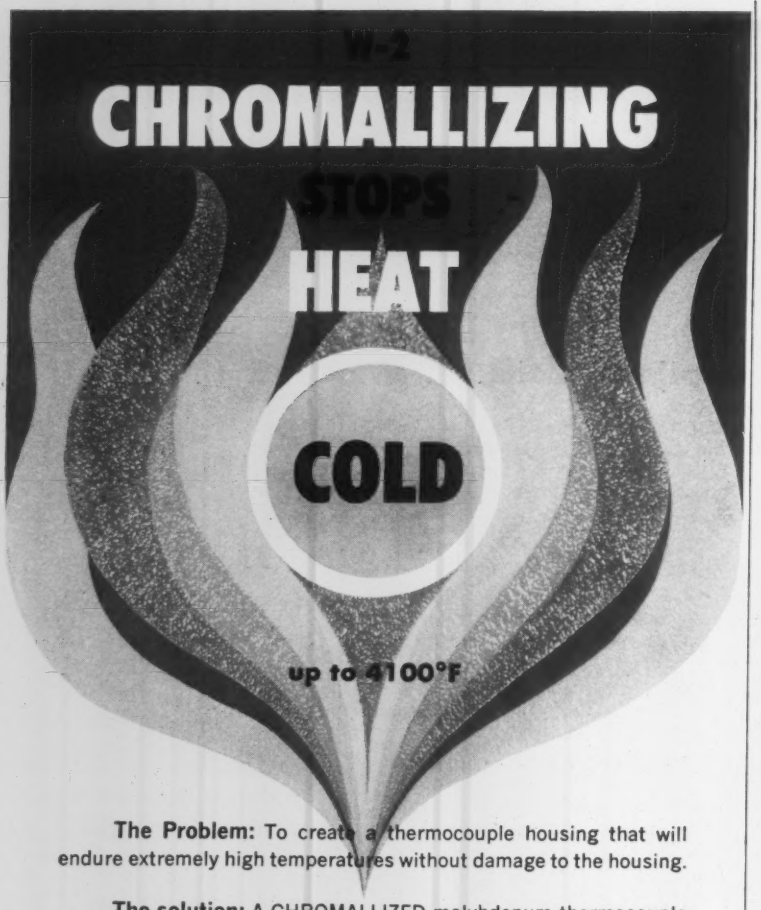

The Problem: To create a thermocouple housing that will endure extremely high temperatures without damage to the housing.

The solution: A CHROMALLIZED molybdenum thermocouple housing. This housing withstands temperatures up to 4100°F. Other applications are structural parts for re-entry vehicles, high temperature testing grips, and ramjet engine components.

What is Chromallizing?
A proven process for diffusing chromium and other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake. the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

CHROMALLIZING processes are also being used to protect superalloys for jet engine parts and to protect ordinary steel against wear, oxidation and corrosion.

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PROPELLEX CHEMICAL DIVISION, EDWARDSVILLE, ILLINOIS
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SINTERCAST DIVISION, YONKERS, N. Y. Machinable carbides & nuclear materials.

For more information, turn to Reader Service card, circle No. 327

against the barium titanate extrusion material, the four segments were made of a special tungsten carbide with only 6% cobalt added—a harder, slightly more brittle material than normal carbide which averages 12% cobalt.

The matching pairs of segments were ground simultaneously in a visual grinder that projects a magnified profile for comparison with an accurate drawing. The four ground segments were then clamped together between two plates, and the o.d. of the complete circle they formed was accurately ground. Finally they were slipped into their holding ring and the assembly ground as one piece to provide the tapered entrance to the die.

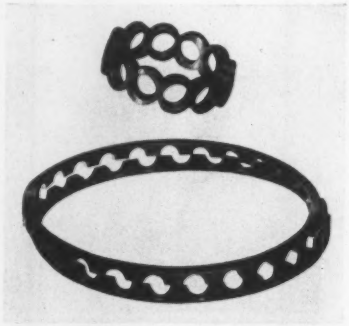
Bearings Improved by Filled Nylon Retainers

The addition of controlled amounts of shredded fibrous glass to nylon bearing retainers enables the bearings to operate up to the maximum allowable limit for standard bearing steels.

The glass filler provides a binder for the relatively unstable FM 101 or FM 31 nylon base material to preserve dimensional accuracy and prevent permanent distortions through a wide temperature range. Other additives, such as molybdenum disulfide and metallic powders, can be incorporated for special applications.

Retainer wear almost eliminated

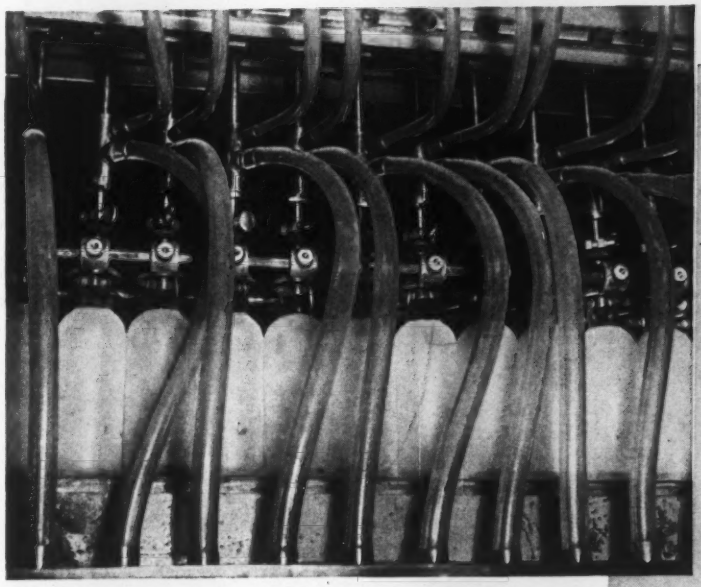
The new retainers, developed by



***Ball bearing retainers** are molded accurately from fibrous glass-filled nylon in many complex shapes*

TYGON® *plastic* TUBING

can be particularly helpful



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- FACE SPACE LIMITATIONS
- REQUIRE VISUAL INSPECTION AND CONTROL OF FLOW

Tough, flexible Tygon plastic Tubing is resistant to an extremely broad range of corrosive gases and chemicals. In fact, it is the standard tubing in laboratories throughout the world, handling virtually all chemicals normally encountered. Clear as glass, it provides perfect visibility of flow.

In non-toxic, odorless and tasteless formulations, Tygon Tubing is almost universally the preferred plastic for handling milk, beverages and liquid or semi-solid dairy products.

Flexible as a piece of string, available in continuous lengths, Tygon Tubing requires few joints or couplings, is quickly installed in minimum space. Its highly-polished bore provides outstanding flow characteristics, prevents interior build-up, permits simple flush-cleaning. Non-aging and physically tough, Tygon retains its unique combination of advantages throughout a long, trouble-free service life.

One of seven standard Tygon formulations will almost certainly meet your requirements. Special formulations have been developed for unusual needs. Over 65 standard sizes up to 4″ I.D. are available.

441F-1

Get complete technical data on the various Tygon Tubing formulations, as well as other helpful information. Write today for free Bulletin T-100.

PLASTICS & SYNTHETICS DIVISION

U. S. STONEWARE

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For more information, turn to Reader Service card, circle No. 389

TEFLON*

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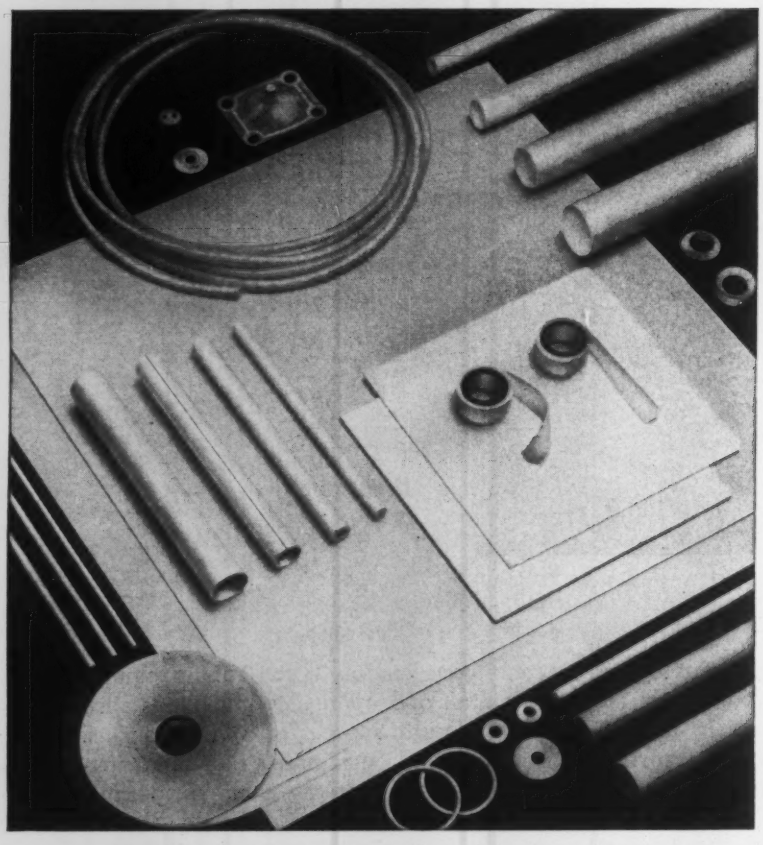

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For more information, turn to Reader Service card, circle No. 340

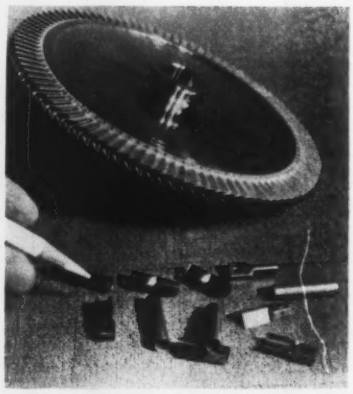
McGill Mfg. Co., Inc., Valparaiso, Ind., can be economically molded to complicated shapes with all critical dimensions molded in, thus avoiding complicated finishing operations. An additional advantage is that retainer wear is virtually eliminated even under conditions of limited lubrication.

The bearing retainers have sufficient tensile and flexing strength to withstand loads up to 20,000 lb. The retainers have some of the cold flow properties of standard nylon, but this is not a handicap because of the relatively low loads on retainer cross bars and sections.

Small Turbine Buckets Made of Sheet Metal

The successful development of sheet metal buckets for turbines powering fuel pumps in a jet engine has cut the cost more than 50% and lightened the 18-lb units by 2 lb according to General Electric Co.

Use of high temperature nickel-base alloy sheet (Inconel X) in the pump's two-stage turbine wheel and nozzle (instead of cast-and-machined parts) permits further weight reductions in the design of the wheel and protective shroud. The low



***Lightweight turbine wheel** with sheet metal buckets designed for use with a jet engine fuel pump. Sheet buckets and blanks in the foreground.*

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Chemloy 719*

use without lubricant!

Chemloy 719 is proving to be the most *universal* dry bearing material ever offered to industry:

. . . because its extremely low coefficient of friction invites use where lubrication is impossible, impractical or undesirable.

. . . because it may be used on both sliding and rotating applications over a wide temperature range.

. . . because it is impervious to practically all known chemicals, solvents or corrosives.

. . . because it is excellent under vibration or shock service conditions.

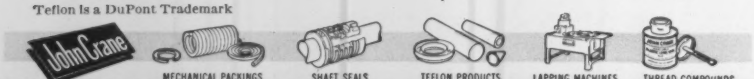
. . . because it will not conduct electricity or cause galvanic corrosion.

Chemloy 719 is available in all basic forms—such as sheet, rod or tubing—or in parts molded or machined to specifications. Get full details.

*The best in Teflon based bearing materials.

Request Bulletin T-120 and Price Sheet No. 126, or send b/p specs. for quotation on molded or machined parts. Crane Packing Company, 6460 Oakton St., Morton Grove, Ill. *(Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ontario.*

Teflon Is a DuPont Trademark



CRANE PACKING COMPANY

For more information, turn to Reader Service card, circle No. 321

inertia of the rotor can also simplify control systems.

According to the company's Aircraft Accessory Turbine Dept., the new units are more reliable than small cast turbines. The wheels are designed to operate at temperatures above 1000 F for 1000 hr without maintenance. While the buckets are welded to the wheel in this design, other conventional methods of attachment such as brazing or pinning can be used to meet other operating conditions.

Personnel Couches for Reentry Craft Tested

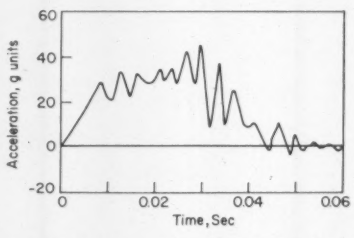
Crushable materials and constructions are being tested for use in personnel couches to dissipate the landing forces in manned space craft.

A report on a general program studying landing energy dissipation in reentry vehicles by L. J. Fisher, Jr., of the National Aeronautics and Space Administration's Langley Research Center, describes the effects of drop tests on a test couch construction.

Crushing absorbs force

The test model consisted of a 4-in. thick piece of semirigid, foamed urethane plastic mounted on an equally thick aluminum honey comb, the two separated by a thin aluminum plate.

Aluminum honeycomb is an efficient material for absorbing impact loads because up to 80% of its depth can be crushed and there is little rebound during impact. However, its stiffness does cause high initial ac-



***Acceleration of a couch** made of aluminum honeycomb and foamed plastic after impact. Vertical impact velocity: 30 fps. Static loading: 1 psi.*

Is there an idea here for you?

Du Pont combines elastomers with fabrics to make versatile FAIRPRENE® – a design material of many uses

Here's how "Fairprene" is serving industry:

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Molded into:
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- Packings
- Meter Bellows

Miscellaneous uses:
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ACRYLIC			●	●	
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Which elastomer-fabric combination is best for your application? The chart above shows the various types of "Fairprene"* available. One of these can probably give you the exact "balance" of properties you need . . . extra-high burst strength with oil resistance . . . flex strength with heat resistance . . . or any degree of the properties offered by the individual components. Clip and mail coupon below for a free booklet giving complete details about "Fairprene" coated fabrics.

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Fabrics Division MDE-2, Wilmington 98, Delaware

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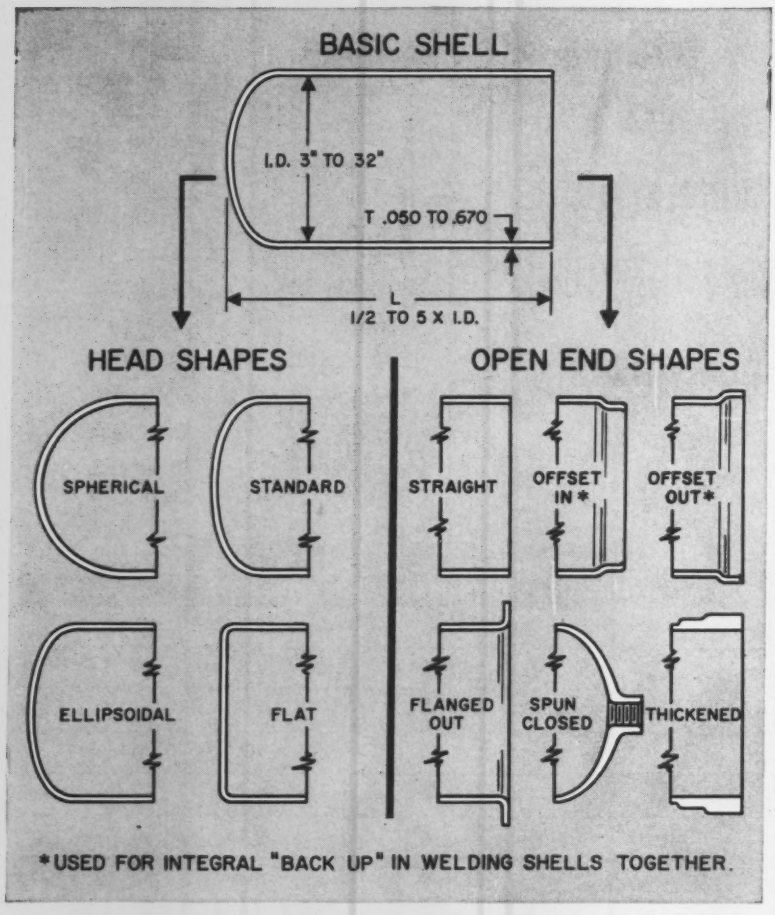
Your ideas...our methods...give you reliable components at low cost



The drawings shown here give you a simple description of the way you can use basic Hackney shells to produce a variety of seamless, lightweight, strong, low-cost rocket motor cases, gas generator housings, control actuator pressure vessels and other missile components.

The basic unit is a cold drawn, deep shell which has uniform wall thickness from top to bottom in ranges from .050″ to .670″. I.D.'s vary from 3″ to 32″. The length of the shell may be from ½ to 5 times the diameter—or up to 110″.

Head shapes—spherical, standard, ellipsoidal, flat or special. *Open end shapes* offer variety—straight cut, offset in, offset out, flanged out, flanged in, spun closed or thickened. *Capacities* begin at 1 quart—go as large as 100 gallons. *Working pressures* range from 100 to 6000 psi, depending upon diameter and wall thickness.

For full details of our facilities and our methods of making components, write to the address below.

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For more information, turn to Reader Service card, circle No. 341

celeration rates on the rebound. These were reduced by adding the foamed plastic.

In the drop test, the model was static weighted about 1 psi to simulate the weight of an occupant and then dropped from various heights, so that it had an impact velocity of 30 fps. As shown in the figure, the average acceleration after impact was about 30 g and the onset rate was about 2400 g per sec.

The sharp peaks in the accompanying curve show that on successive impacts the columnar failure of the honeycomb cells was not distributed uniformly, so that at these peaks the test weight "virtually" bottomed before the impact velocity had been completely dissipated.

Metal Films Perform Electronic Function

Electron tunneling which has previously proved useful in carefully prepared semiconductor materials has now been observed in devices of simpler configuration.

Ivar Giaever, physicist at General Electric Co.'s Research Laboratory, Schenectady, N.Y. has demonstrated that tunneling occurs in a configuration of two metal films separated by a thin insulating layer, with one or both of the films in the superconducting state, i.e., offering no resistance to the passage of electrical current.

The GE discovery, like the previously discussed molecular electronic concept developed by Westinghouse (M/DE, Mar '60, p 12), is expected to bring about revolutionary changes in the design of electronic equipment. For example, it may be possible to make a microminiature electronic device that would function as a switch, diode, triode, resistor or capacitor by simply depositing metal and insulating layers on a suitable substrate.

What tunneling is

Giaever says the tunneling of electrons through thin insulating layers can best be understood by thinking of charge-carrying electrons as waves rather than as particles. When the charge-carrying waves strike a barrier, virtually all of them will

For more information, circle No. 412 ➤

HANDWHEEL MOLDED FOR JACOBS CHUCKS BY HOLYOKE PLASTICS CO., HOLYOKE, MASS. DeBELL & RICHARDSON, INC., CONSULTING ENGINEERS, OF HAZARDVILLE, CONN., DESIGNED HANDWHEEL AND HELPED SELECT MATERIAL. PRECISION GEAR OF STEEL IS MOLDED INTO PLASTIC.

G-E PHENOLIC HELPS JACOBS CHUCKS REACH A WIDER MARKET

Jacobs Manufacturing Co. of W. Hartford, Conn., wanted to make a low-cost chuck for popular-priced lathes. But the new product had to maintain Jacobs' reputation for quality. The handwheel, for example, had to be rugged enough to withstand rigorous use in machine shops, yet economical to produce.

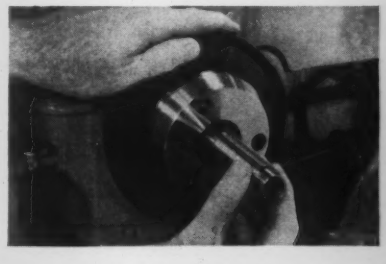
General Electric technical service people helped to find the answer — *G-E 14012*. A severe testing program demonstrated that this phenolic molding compound had the high strength and impact resistance to take rough treatment. Spun at 10,000 rpm after deliberately cracking the plastic, the wheel remained intact. G-E 14012 is unaffected by cutting oils—an important consideration. It molds to a glistening finish with no need for after-machining. Shrinkage is minimal.

Jacobs estimates that production costs for an equivalent wheel of metal would be 2 or 3 times as high. This is one reason why the new chuck can be sold for about 70% less than units of comparable quality, and is an example of the G-E Value Concept in action.

How can the G-E Value Concept help *you* make a better product? The G-E Technical Service staff will be glad to help you find out. G. E. makes a broad line of phenolics to meet diverse and exacting specifications. If you'd like to know more about these outstanding materials, write to General Electric Company, Section M-161, Chemical Materials Department, Pittsfield, Mass.

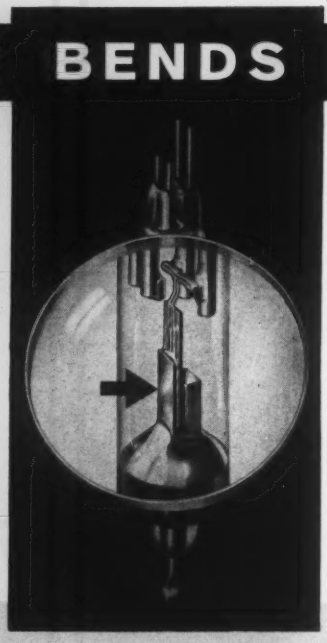
Phenolics-first of the modern plastics...first in value

GENERAL ELECTRIC



Billions Of BENDS

Prove SANDVIK SPRING STEEL'S *Fatigue Resistance*



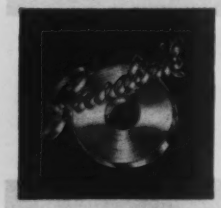
Here is another example of the extraordinary fatigue life you can get from Sandvik Spring Steel.

C. P. CLARE & CO. uses Sandvik 12W12C1 Steel as the spring support for the armature assembly in their line of Mercury-Wetted Contact Relays. Here, from a letter by Mr. C. H. Smith is what they say about it.

"The steel piece deflects through a complete cycle — once for each operation of the relay. Sandvik Steel was chosen for its excellent fatigue resistance. When you realize Clare HG relays have a life expectancy measured in billions of operations you can see the importance we place on selecting top grade materials."

The steel used for this application is only one of Sandvik's many types of specialty spring steels. Each type provides consistent, predictable results for a specific range of application.

For more information on Sandvik Specialty Steels and how they can be applied advantageously, use the coupon below or send us a note on your letterhead.



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☐ Please have your representative phone for an appointment.

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88-229

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be reflected back from the barrier. But a portion of the waves will pass through the barrier if it is thin enough. If a conductor is present on the other side of the barrier, the presence of tunneling waves may be detected as electric current.

Superconductivity has profound influence on tunneling

In experimenting with electron tunneling through ultra-thin insulating films, Giaever found an unexpected effect when one of the conducting metal films was a superconductor. Instead of a straight-line graph showing that current increased proportionally with voltage, an S-shaped curve was produced, indicating that an effect similar to that in the semiconductor tunnel diode might be involved. Giaever found that a region of "negative resistance," in which the current decreases with increasing voltage, could be observed if both metal films were superconducting.

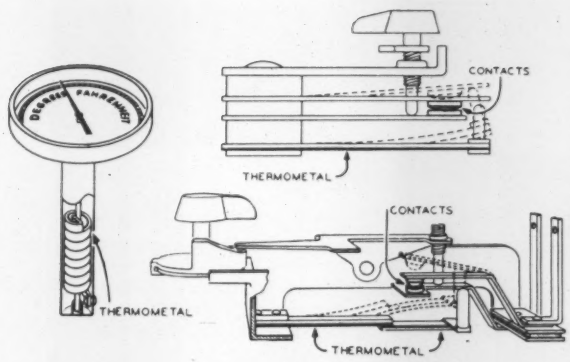
Negative resistance results from the fact that certain energy levels in a superconductor are "forbidden" to electrons. Any electrons in one metal film that have energies equal to forbidden energies in the other metal film cannot tunnel through the intervening insulating film. Therefore these forbidden energy gaps in superconductors have a profound influence on the tunneling currents and lead to the unique behavior discovered by Giaever.

Work done on lead, tin, aluminum films

Most of Giaever's experiments have been done with films of aluminum, lead, idium and tin, all of which become superconductive at near liquid helium temperatures. A considerable number of other metals are expected to show the same effect. In almost all of the experiments, aluminum oxide was the insulating layer, although Giaever has obtained proof of electron tunneling through tantalum oxide, columbium oxide and nickel oxide as well.

More research needed

A great deal of applied research and development will be required to evolve practical devices based on the new concept, says GE. Also, the requirement of cryogenic temperatures for the suggested electronic devices will be a handicap, but per-



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Leading manufacturers rely on the dependable performance of Wilco Thermometal in electrical appliances, thermal cutouts, heating controls and many other applications involving the indication and accurate control of temperatures, electrical currents, voltages, etc. Thermometal is supplied in strip form, rolled and slit to close tolerances and tempered to specification. Thermometal elements and sub-assemblies are also supplied to specifications, with or without contacts attached. Send for literature.

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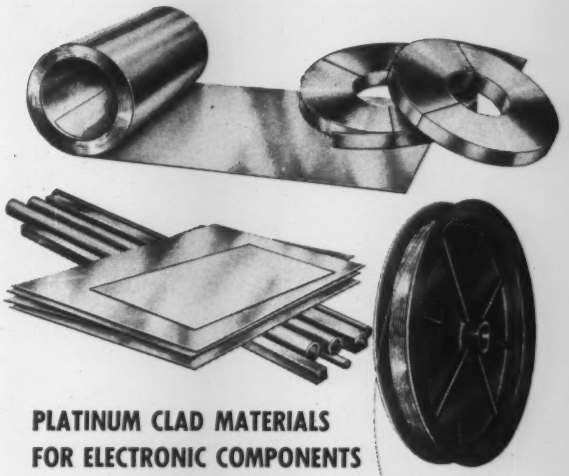

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Platinum clad wire, sheet and tubing provide all important desirable characteristics of the precious metals at minimum cost for electronic components. Pure or alloyed platinum is securely bonded to base metal with continuous pore-free platinum cladding guaranteed for ensuring reliable functional performance at elevated temperatures. • Gauge of platinum metal can be specified to requirements for economical parts and equipment fabrication. Write for literature.

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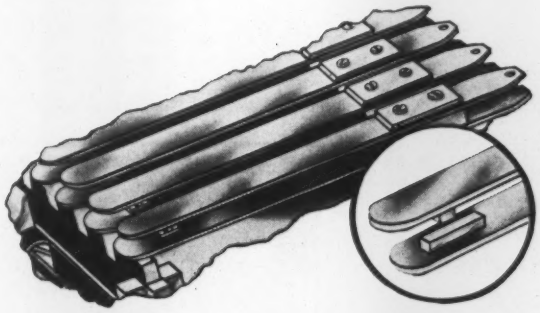

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High reliability welded contacts and contact assemblies available for your relays. Weld strength guaranteed. • Overall contact height held within ±.00025. Assemblies are available in gold, platinum, palladium, silver and their various alloys—both solid and laminated. Single contact usable for various contact ratings, for wet and dry circuitry—assemblies protected for shelf life and handling. Designs for attachment to header by welding or brazing. Complete electrical and mechanical design services available.

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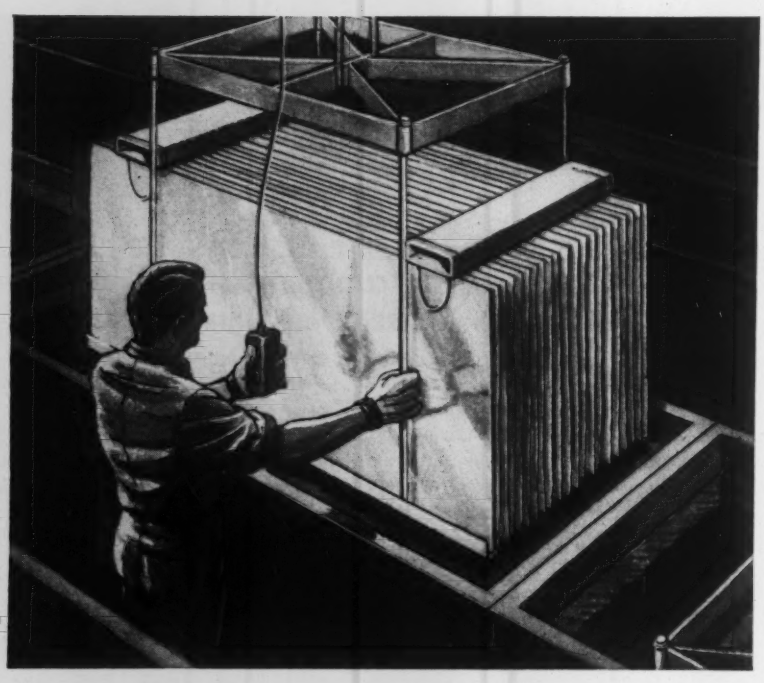

Stencil inks, shop soils disappear fast in Oakite Aluminum Cleaner 164

Here is a heavy duty yet perfectly safe alkaline cleaner for all aluminum alloys. Parts immersed in a tank of Oakite 164 emerge free of even the most tenacious identifying inks, greases and other shop soils. There's no etching at all.

Air agitation of this efficient, non-foaming solution speeds cleaning action, although Oakite 164 works efficiently even without this aid.

To meet *any* aluminum cleaning requirement—ask Oakite. There's a *whole line* available—solvent as well as alkaline. Whichever is recommended, you can be certain of service as well as safety. Send for Bulletin B-6395. Oakite Products, Inc., 45B Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

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over 50 Est. 1909 SCIENCE

years' leadership in industrial cleaning

For more information, turn to Reader Service card, circle No. 331

ENGINEERING & DESIGN

haps not too serious a one.

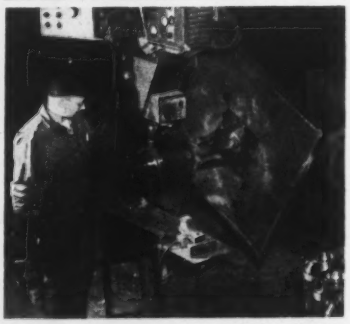
The new GE discovery is one of several recent developments that are practical results of the solid state approach to materials engineering (M/DE, Sept '60, p 133).

Precoated Stampings Withstand Forming

Prepainted aluminum sheets stamped into frames and covers for electronic decimal counting units has halved fabrication time and reduced cost 60% according to the Berkeley Div. of Beckman Instruments Inc.. Richmond, Calif.

Redesigning the units with enameled coils of aluminum supplied by Bridgeport Brass Co was the only design change from using bare 5005-H34 alloy aluminum for the frames and 6011-O aluminum for the covers. This modification eliminated painting and curing after stamping and, consequently, the need for a separate paint finishing department with its attendant labor costs and space requirements.

Although the stamping operations extensively elongate the metal, the high resiliency and abrasion resistance of the enamel prevent cracks, forming marks or chipping.



Welding 4130 steel—Use of submerged arc welding plus good fixturing has reduced the tendency toward cracks and porosity during welding of a 4130 steel cylindrical shell to a wrought iron generator frame (0.03% carbon). According to Lincoln Electric Co., the weld is completed in two successive passes, at a rate of 16.4 ipm. A ⅛-in. mild steel electrode is used with a neutral flux.

This can be the important thing you buy when you buy aluminum

WITH OUR ENTIRE OPERATION UNDER ONE ROOF, your order gets personal attention *all* the way. Our own truck fleet, operated by Fairmont men who specialize in aluminum handling, guarantees delivery unequalled for speed and dependability.

THE PROMISE THAT'S KEPT! Brave words. When you deal with Fairmont, they're true. In a survey recently conducted by a hard-headed industrial publisher, Fairmont ranks first with aluminum fabricators for fulfilling promises and commitments. This sums up everything an aluminum source should give you.

It means quality-control—Fairmont comes through every time with sheet, coils, circles, custom-produced to your detailed specifications. It means availability—every Fairmont mill product is rolled every day. It means delivery—dependable, as scheduled.

And it means mature, experienced Fairmont field representatives who make it their business, not to "sell" you, but to *help you buy* according to your own best interests. When the Fairmont man shakes your hand, he means it. So does the company behind him.

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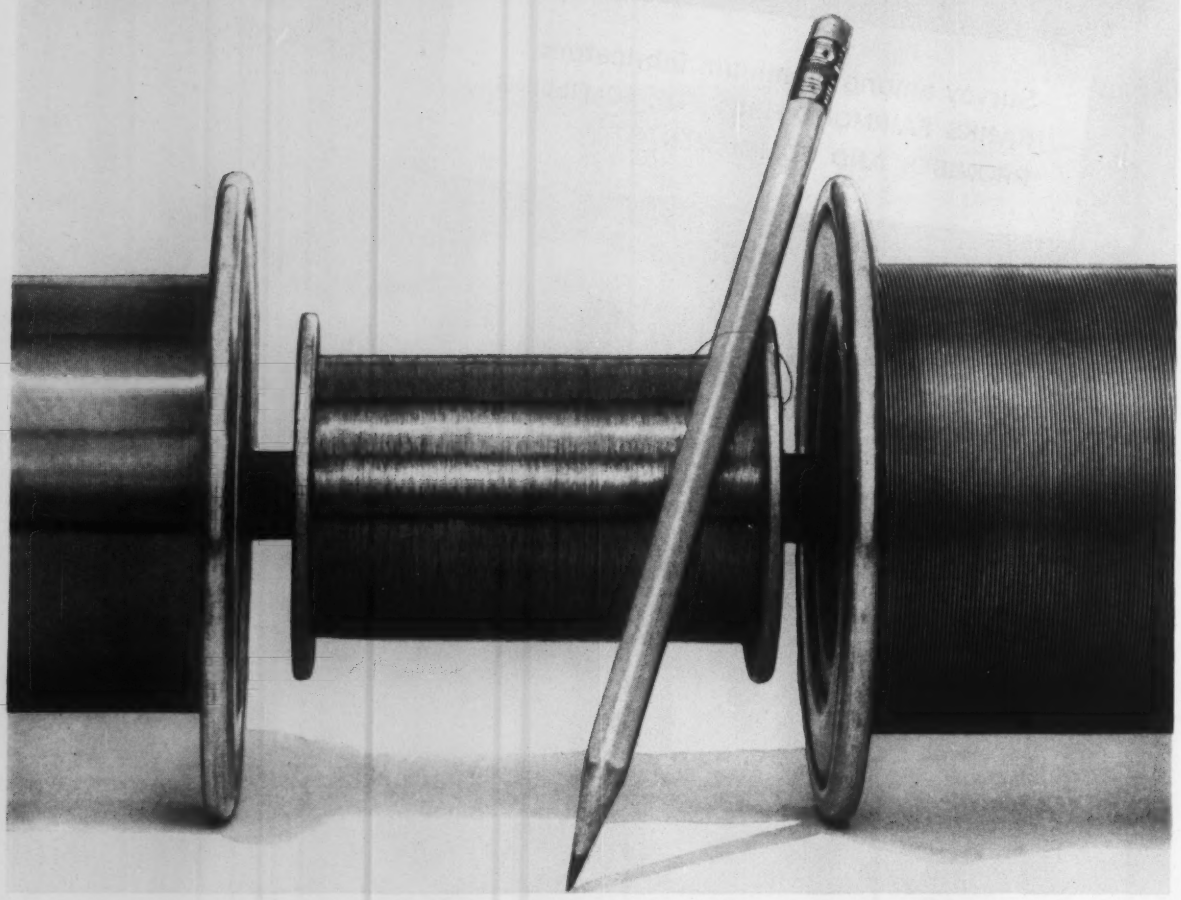
SYLVANIA MAKES ALL THREE—ALLOY, CLAD AND PLATED WIRE



Where to start when you're writing specs

—Let Sylvania give you an unbiased recommendation on wire

When you're designing and specifying materials for special purpose applications, selection of the proper wire can be all-important. Clearly, there are wide variations in corrosion resistance, oxidation resistance, strength and conductivity.

That's why more and more engineers *start* with Sylvania when they specify wire. Of all major manufacturers, only Sylvania makes all three types of bare wire – alloy, clad and plated. Sylvania makes them in a full range of sizes, too—.002″ to .250″. Each and every one retains optimum characteristics up to recommended operating temperatures.

With such a complete line, you can be sure that a Sylvania recommendation is unbiased. It's based on *your* needs—*not* restricted by a limited line. Full details—for future use or help on a present project—are yours at Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania. Call or write.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

For more information, turn to Reader Service card, circle No. 334

(continued from p 23)

better processability.

Similar to other CFE's

Typical properties of the two materials are shown in the accompanying table. They are quite similar to properties of other CFE fluorocarbons.

The primary features:

- Chemical inertness—Virtually unaffected by inorganic acids, alkalis or oxidizing agents, and most organic compounds.
- Zero moisture absorption.
- Resistant to heat and cold. Type VK is serviceable at temperatures up to 350 F; type TVS to 390 F. In thin sections the materials can be flexed at −320 F.
- Toughness. Good impact strength, abrasion resistance and compressive strength.
- Excellent electrical properties. High volume and surface resistivity, low dielectric constant and power factor. These properties are relatively insensitive to changes in temperature or frequency.
- Noninflammable.
- Weather resistant. Unaffected by sunlight after one year outdoor weathering.

***Medical equipment** can make use of the sterilization qualities of the new fluorocarbon. The new resins have received FDA approval.*

Like all CFE fluorocarbons, Halon resins are crystalline polymers. Properties can be altered somewhat by altering crystallinity, either by controlling rate of cooling after forming, or by controlling rate of cooling after annealing. In thin sections the materials can be made transparent by rapid quenching. In general, rapid cooling results in toughness and flexibility; slow cooling results in higher rigidity and opacity.

Where they will be used

Approved by the Food & Drug Administration, Halon resins may find uses in food packaging and as components for food processing equipment. Other expected applications include electric cable jacketing, antiseptic medical equipment, chemical gasketing, and electrical components where moisture absorption is a factor.

The comparatively low price of the material may cause its use in applications where the superior resistance to chemical and heat of TFE fluorocarbon is not required, but where the lower cost of TFE has caused it to be selected in place of CFE fluorocarbon. (Types of TFE fluorocarbons possessing maximum heat and chemical resistance require processing by comparatively costly sintering techniques similar to those used in powder metallurgy.)

Machining Technique Is Fast, Accurate

A new electrolytic machining technique can shape parts from the toughest alloys in as little as one-tenth the time of conventional machine tools. The technique was developed by Battelle Memorial Institute in research supported by Steel Improvement and Forge Co., 970 E. 64th St., Cleveland 3, Ohio.

Battelle says the process is unique in that its effectiveness is not dependent on the hardness of the metal, and thus, offers a solution to the problem of machining hard, high strength metals. The method has been used to machine rough forged jet turbine blades to 0.003-in. tolerances in 5 to 10 min, an operation which formerly took 1 to 2 hr to perform by grinding.

Process differs from other electrolytic methods

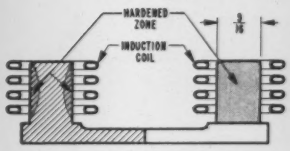
The Battelle-developed process differs from other methods which use

LepeL
HIGH FREQUENCY
Induction
HEATING UNITS

Lepel induction heating equipment is the most practical and efficient source of heat developed for numerous industrial applications

Typical Induction Heating Applications

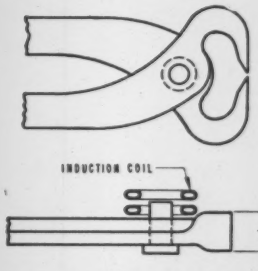
Steel Bosses Selectively Hardened



Bosses on part shown are locally hardened to increase resistance to wear and plastic yielding. Surface hardening by induction provides hardness pattern indicated and hardness of Rc 57/59 for 1040 steel when quenched in water.

Our engineers will process your work samples and return the completed job with full data and recommendations without cost or obligation.

Hot Forming Aids Production Assembly of Nippers



The ends of high-strength steel rivets are selectively heated to 1700° F for hot upsetting. Design of coil permits movement of upsetting tool through the coil.

WRITE FOR NEW LEPEL CATALOG

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55th ST. & 37th AVE., WOODSIDE 77, N. Y.
CHICAGO OFFICE: 6246 WEST NORTH AVE.

For more information, circle No. 408

A square of Kentanium K161B (top) and one of heat-resistant 35 chrome —15 nickel alloy (bottom) show the effect of 120 hours' exposure to 2000°F. in an unsealed muffle furnace.

If you need a design material that can take temperatures up to 2200°F. under continuous operation, or higher temperatures for short duration . . . there's a good chance Kentanium can solve the problem.

In addition to its outstanding oxidation resistant qualities, Kentanium has other problem-solving properties. For example . . . the highest stiffness-to-weight ratio of any material, as Kentanium is only ⅔ the weight of steel . . . and has a YME up to 60-million psi. Kentanium also has high resistance to abrasion, corrosion, and great strength at high temperatures.

For temperature sensing elements, rotary seal rings, hot rod mill guide inserts, nuclear reactor components, balls for pump check valves, spinning tools for hot metals . . . and maybe for *your* product . . . Kentanium offers many advantages.

For more information, send for these two booklets: B-444-A, "Kentanium," and B-666, "Proven Uses of Kennametal and Kentanium." KENNAMETAL INC., Latrobe, Pennsylvania. 33516

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For more information, turn to Reader Service card, circle No. 344

the electrolytic metal removal principle in three ways:

1. It can produce complete parts in addition to sinking cavities.
2. It uses no rotating cutting wheels.
3. Power is supplied through a simple rectifier instead of complex electronic circuits.

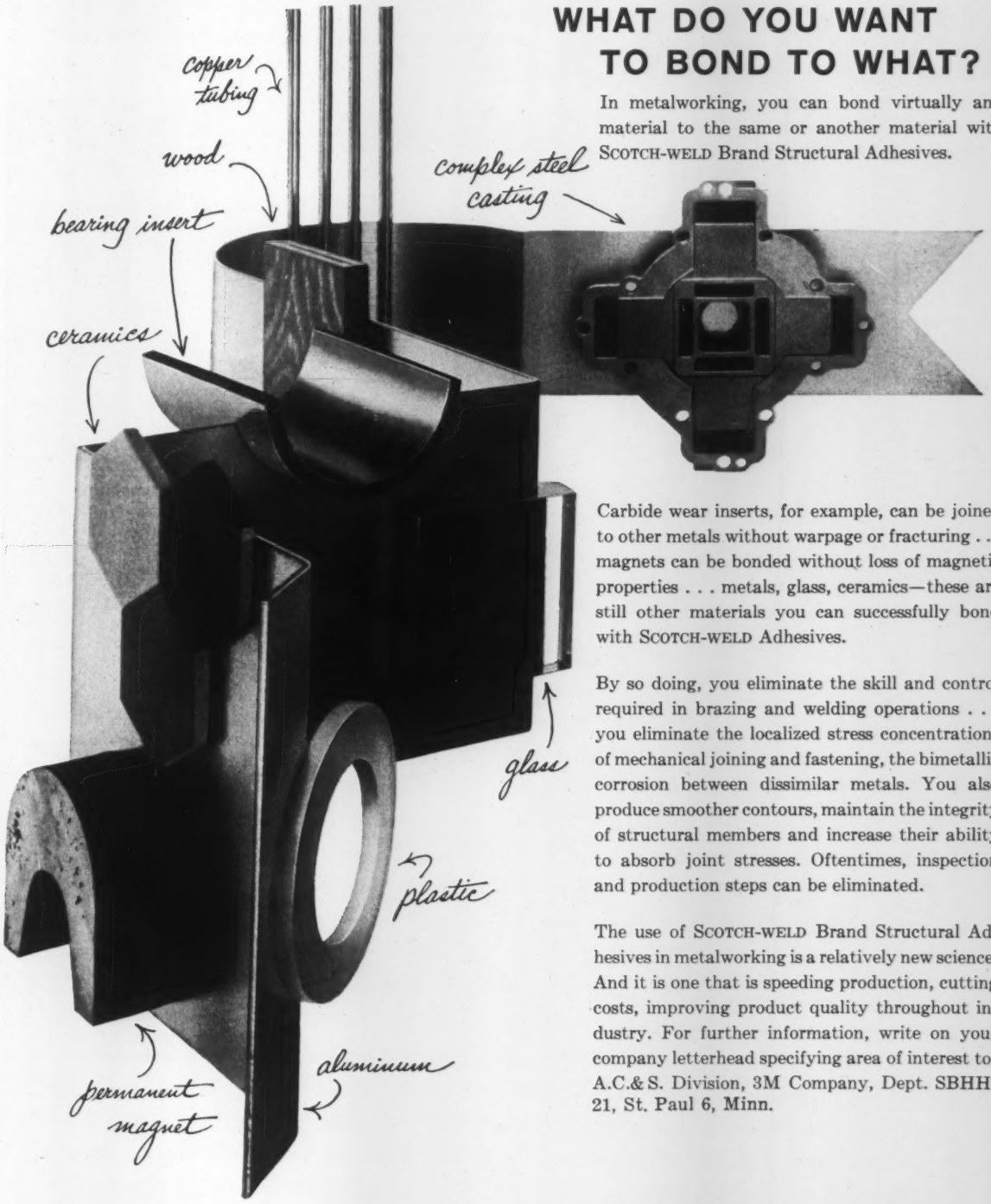
Battelle says that the process' big advantage is not the time saved but the absence of mechanical damage to the surface of the workpiece. Because there is no tool pressure on the workpiece, very thin sections can be shaped without deformation. Also, the shaping process produces no metallurgical change on the surface of the workpiece as conventional machining does.

How technique works

Metal is removed without arcs, sparks or high temperatures by passing direct current between the workpiece and an electrolyte. The current removes electrons from the workpiece, converting the surface atoms into positively charged ions that dissolve the electrolyte.

To produce a part, a rough forging or piece of metal stock (anode) is placed between shaped electrodes (cathode) and electrolyte is pumped

***Electrolytic cut-off** of a tungsten rod is carried out on this machine. It features a rapidly rotating ⅛-in. thick stainless steel electrode wheel which directs a rapid flow of chemical solution between the wheel electrode wheel through the chemical and workpiece. An electric current passed from the workpiece to the solution does the cutting.*



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In metalworking, you can bond virtually any material to the same or another material with SCOTCH-WELD Brand Structural Adhesives.

Carbide wear inserts, for example, can be joined to other metals without warpage or fracturing . . . magnets can be bonded without loss of magnetic properties . . . metals, glass, ceramics—these are still other materials you can successfully bond with SCOTCH-WELD Adhesives.

By so doing, you eliminate the skill and control required in brazing and welding operations . . . you eliminate the localized stress concentrations of mechanical joining and fastening, the bimetallic corrosion between dissimilar metals. You also produce smoother contours, maintain the integrity of structural members and increase their ability to absorb joint stresses. Oftentimes, inspection and production steps can be eliminated.

The use of SCOTCH-WELD Brand Structural Adhesives in metalworking is a relatively new science. And it is one that is speeding production, cutting costs, improving product quality throughout industry. For further information, write on your company letterhead specifying area of interest to: A.C.& S. Division, 3M Company, Dept. SBHH-21, St. Paul 6, Minn.

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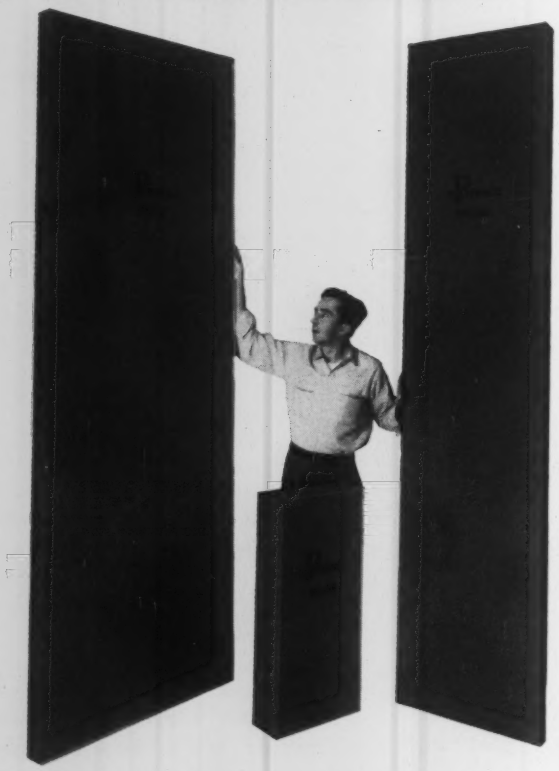
NEW MASSIVE MC NYLON PLATE NOW AVAILABLE!



• Huge MC Nylon plate—the largest ever produced—is now available for wear plates, panels, tooling, fixtures and other applications which need nylon's unique mechanical or structural properties.

Polymer's exclusive revolutionary new processing techniques make production of large plate practical with price reductions of 15% under nylon plate presently available. Standard stock availabilities now include thicknesses from ½" up to 4" and in 2' by 4' sections. Availabilities to date were limited to 1½" maximum thickness in 10" widths. MC Nylon now opens new design possibilities and manufacturing economies. On special order plates of over 6" thickness in sections of 4 foot widths and 10 foot lengths can be supplied.

In tubular bars, the specially formulated bearing material now costs less than continuous cast bronze bushings of similar size, with prices up to 50% below other nylons.

MC Nylon tubular bars are made in OD's from 2" to 15" with wall thicknesses of ⅜", ½", ¾" and 1". Rod up to 17" diameter is also available with special larger sizes and shapes made to order. Supplied in Polypenco blue.

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Electroshaping machine *shown here has turned out more than 15,000 finished turbine blades made of a variety of superalloys.*

under pressure into the space between the electrodes and workpiece. The electrodes are moved in simultaneously as the electric current dissolves the workpiece to the desired shape.

Current requirements for the electrolytic process range up to 1500 amp per sq in. of workpiece at 3 to 12 v to achieve a penetration rate of 0.05 to 0.1 ipm. However, for most operations a 100-500 amp current is sufficient, according to Battelle.

The shaped electrodes, which are not subject to wear, can be made of any electrically conductive material. The electrolytes, selected according to the metal to be machined, are solutions of readily available commercial chemicals.

Availability

Steel Improvement and Forge Co. is presently manufacturing a line of electroshaping machines based on the new principle. C. H. Smith, Jr., president of the company, says that to date no decision has been made whether to lease the machines to a

PROPERTIES of most engineering materials can be found in M/DE's *Materials Selector* reference issue, published last November. Names and addresses of suppliers are also listed.

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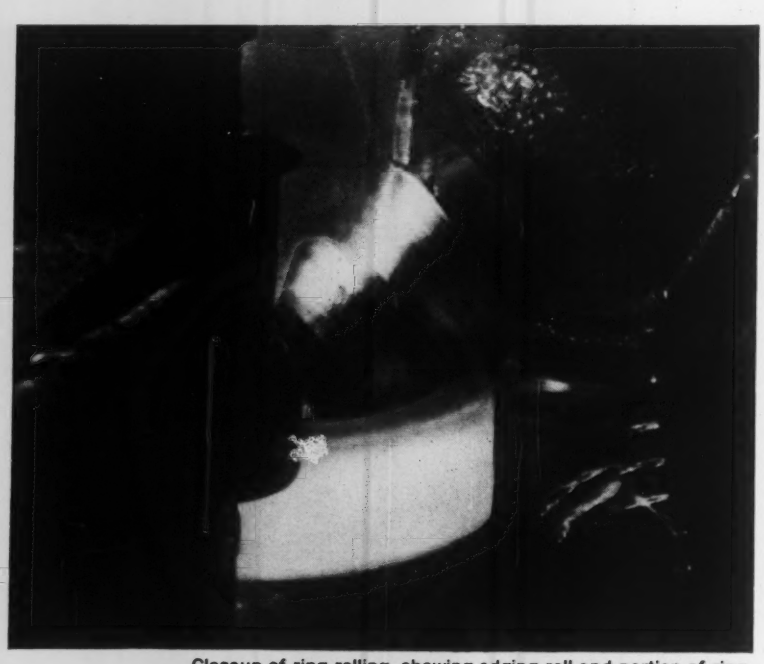

Closeup of ring rolling, showing edging roll and portion of ring.

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P. O. Box 478, Dept. MDE Pittsburgh 30, Pa.

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What's new IN MATERIALS

customer or sell them outright with a license to use the machines with or without a technical service contract. KEY NO. 609

Tough Polyethylene Insulates Wires, Cables

An improved, high density polyethylene compound for wire and cable applications has been introduced by Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17.

Compound combines toughness with resistance to cracking

The material, called Bakelite DGD-4100, is said to combine the advantages of greater toughness, high abrasion resistance, reduced compressibility and better heat deflection with greatly improved resistance to stress cracking and thermal embrittlement.

In standard IPCEA (Insulated Power Cable Engineers Assn.) tree wire abrasion tests, the new material withstood over 1,500,000 cycles which is 50% better than other high density polyethylenes tested.

When tested for thermal embrittlement resistance, the compound showed no failures after 5000 hr of Underwriters Laboratory heat shock test. In tests for resistance to environmental stress cracking (immersed in Igepal CO-630), time to initial failure at 125 F was greater than 500 hr. KEY NO. 610

Two New Methods for Plating Nickel

Two new nickel plating techniques have been introduced by Udylite Corp., 1651 Grand Blvd., Detroit 11. One method produces a sulfur-free, semibright finish; the other produces a satin-type finish.

1. Sulfur-free finish

A big advantage of the sulfur-free, semibright nickel plating technique, says L. V. Nagle, executive vice president of Udylite, is the lack of harmful breakdown products in the plating bath. Nagle says the process is expected to reduce costs and improve the appearance and durability of electroplated nickel finishes on

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automotive parts, appliances and other metal products.

The new process, called N2E, involves the simultaneous addition to the plating bath of two addition agents, Brightener E and Brightener 2N. Brightener E is effective in the low and intermediate current density ranges, and 2N is effective in the intermediate and high current density areas. Combined, the addition agents are said to promote uniformity and consistency on uneven surfaces of formed metal parts.

The process can be used in any plating sequence in which other semibright nickel processes are now used, according to Udylite. And it can be used at bath temperatures up to 150 F for high speed plating.

KEY NO. 611

2. Satin-type finish

Udylite's other new plating process, Satylite, produces a satin-type finish directly from the plating bath. Details as to how the process works have not been disclosed.

The producer says the method can be used to deposit nickel on metal furniture, automotive trim, camera

Surfacing mat—Famco, Inc., P. O. Box 35, Highland Park Station, Louisville 9, Ky. is offering a new surfacing mat, shown above, that is said to incorporate the handling characteristics of a surfacing mat and the molding characteristics of a veil. The mat, called Type 500-H, is suited for use in operations where deep drawn or complicated shapes are involved. The mat is available in thicknesses ranging from 5 to 30 mils. It has a silane finish.

KEY NO. 613

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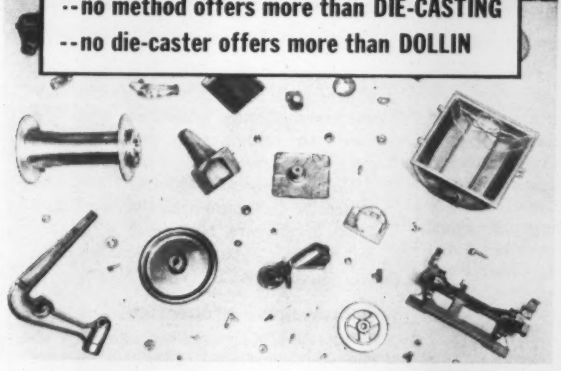

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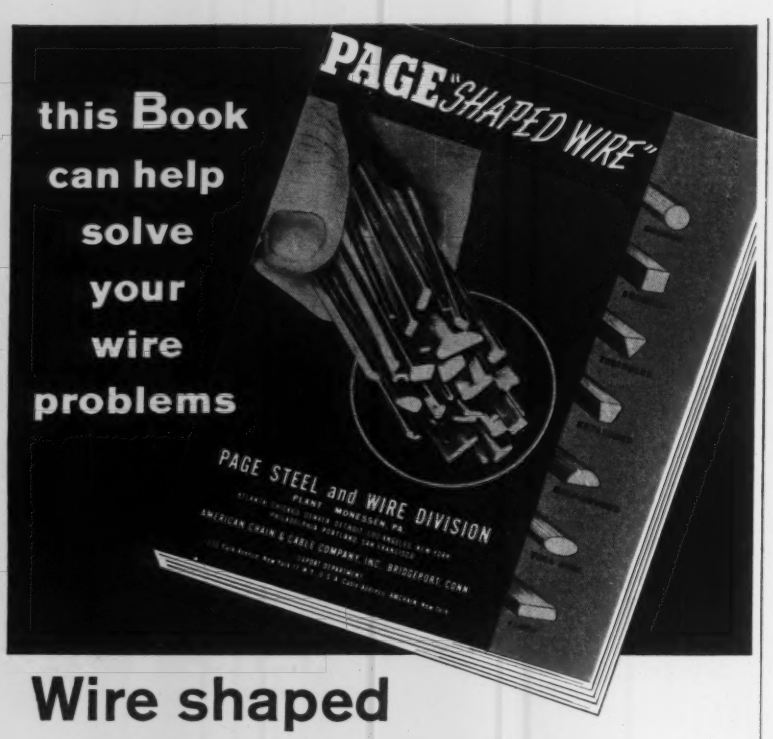

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Write for Book • **DH-1226** *contains data on carbon and alloy steel weights—explains how to calculate areas of common shapes—lists physical properties of steel wire. Write us at Monessen, Pa., for a copy.*

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parts, costume jewelry, drawer pulls, hinges, marine hardware, surgical instruments, plumbing fixtures and household appliances.

A big advantage of the technique is the ease with which a two-tone effect can be obtained. For example, buffing raised, accessible surfaces to a high luster creates an attractive contrast between the bright buffed surface and the surrounding satin finish that has been obtained directly from the plating bath. **KEY NO. 612**

Flocked Plastics Film

Rayon-flocked polyester film is now available from Cellusuede Products, Inc., 500 N. Madison St., Rockford, Ill. The material is soft and velvet-like in appearance, but has high tensile, tear and impact strength, according to the producer.

The rayon flocked film is available in 36-in. wide rolls 50 yd long. It can be used for decorative purposes or for cushioning and vibration dampening applications. **KEY NO. 614**

Epoxy Adhesive for Honeycomb Structures

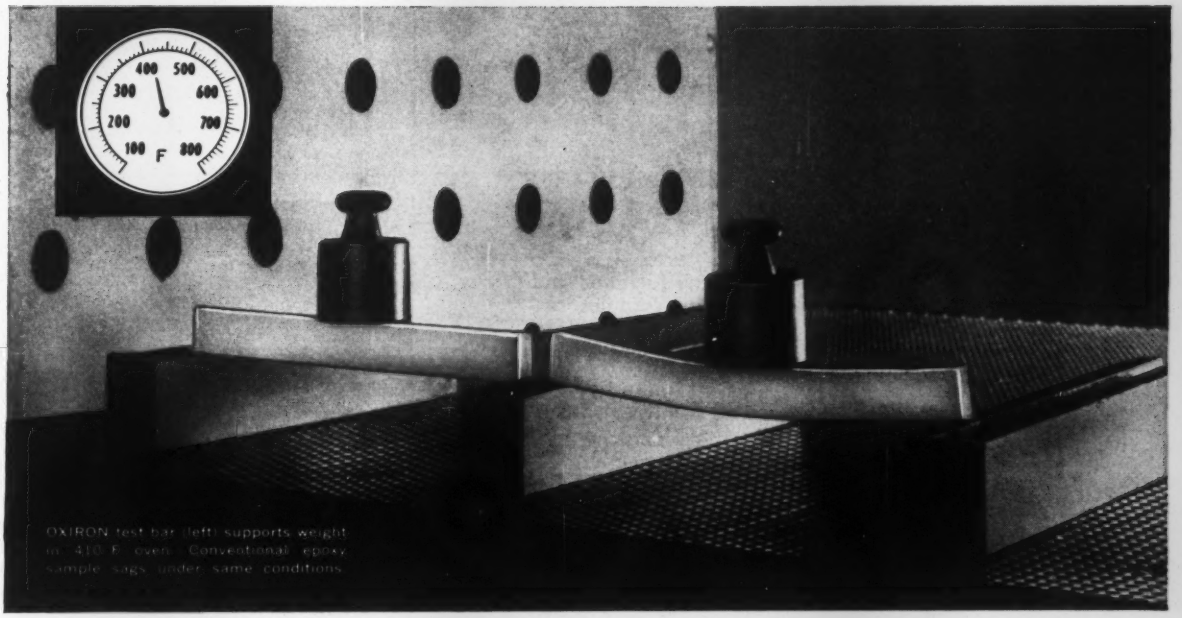
A new supported epoxy resin film adhesive is said to combine the advantages of film adhesives with the excellent self-filleting properties of epoxy adhesives.

Called Scotch-Weld AF-106, the adhesive is commercially available from Minnesota Mining & Mfg. Co., Adhesives, Coatings and Sealers Div., 900 Bush Ave., St. Paul, Minn.

Advantages, properties

The producer says the adhesive offers many design and cost saving advantages in bonding metal and paper honeycomb cores to metal facings in honeycomb sandwich constructions. For example, the adhesive provides uniform adhesive thickness throughout the assembly, controlled confinement of adhesive to the immediate bonding area and clean bonding operations. Application procedures are simple.

The adhesive has good creep resistance under constant stress, good adhesion to metals and plastics, and excellent resistance to water, 20%



OXIRON test bar (left) supports weight at 410 F. even. Conventional epoxy sample sags under same conditions.

NEW OXIRON EPOXY RESINS OFFER UNUSUAL HIGH TEMPERATURE PROPERTIES

Even after long exposure at elevated temperatures, OXIRON resins have high flex strength and show little weight loss. Anhydride-peroxide-cured OXIRONS resist deformation over a broad range of temperatures. The gentle rise of their heat distortion curves demonstrates why these resins are acceptable for practical use at temperatures far above the heat distortion point (see diagram). In addition to high-temperature strength, OXIRONS have excellent electrical properties which they retain over a wide range of temperatures, show superior resistance to creep at elevated temperatures.

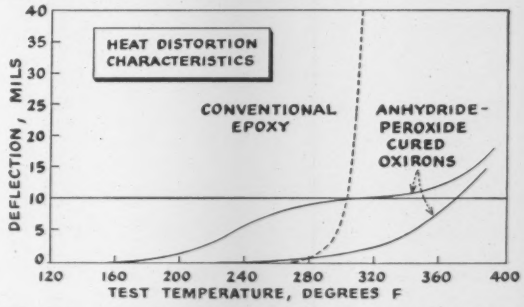
OXIRON resins are unique as epoxies, because they are epoxidized polyolefins rather than bisphenol-epichlorohydrin-type reaction products. Since they provide *10 or more* reaction sites per "monomer" unit, they have a remarkable degree of chemical versatility, as their cure reactions show. The resins are available in a wide range of viscosities and offer an unusual combination of advantages:

Novel Cure: OXIRONS can be cured through their reactive double bonds as well as epoxy and hydroxyl groups. They are the only epoxy resins that can be cured with peroxides. However, conventional epoxy curing agents may also be used. OXIRONS have high reactivity with anhydrides and dibasic acids at low temperatures . . . provide increased pot life with polyamines . . . react with a variety of other curing agents such as polyphenols, Lewis-type catalysts, polysulfides.

Economy: Low-cost curing agents may be used in high proportions.

Low Density: 20% lighter than ordinary epoxies—cured resins likewise have lower density.

Outstanding Chemical and Electrical Resistance: Excellent resistance to alkalis, acids and solvents—cured resins have good electrical properties.



This graph shows that—unlike conventional epoxy resins—the heat distortion curve of OXIRONS does not break sharply with temperatures . . . can be used above the heat distortion point itself.

Send for our Epoxy Data Booklet which describes OXIRON *2000, 2001, and 2002 in detail, contains curing information and gives suggested uses. If you'd like a sample, let us know what application you have in mind so that we can supply a suitable resin.*

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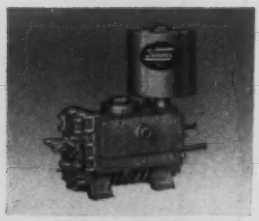

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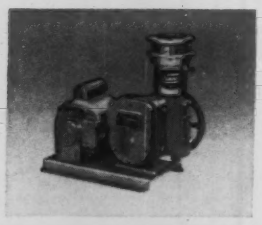

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Bulletin 3800.1
Bulletin 3811.1

VACUUM VALVES

A new series of Sweat Fitted Bronze Bellows Valves is now available in the comprehensive KINNEY Line of Vacuum Valves. Featuring a design that permits replacement of bellows without disturbing installation, these new Valves are available in 1", 1½", 2" and 3" sizes.

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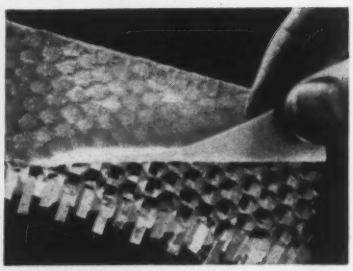

***Applying** epoxy resin film adhesive to aluminum honeycomb core prior to assembly of honeycomb sandwich.*

salt spray, hydraulic oil and aromatic fuel. It produces metal-to-metal bonds with shear strengths over 2000 psi at 75 F, and can be used over the temperature range −67 to 300 F.

Curing

According to 3M, maximum strength is obtained with an optimum cure of 1 hr at 350 F under 25-50 psi pressure. However, high bond strength can be obtained with a cure as low as 2 to 3 min at temperatures in the 400 to 450 F range.

KEY NO. 615

Asbestos Paper

A new grade of highly purified, inorganic paper has been announced by Raybestos-Manhattan, Inc., Asbestos Textile Div., Manheim, Pa. The paper, designated No. 7504, is a combination of glass cloth and long fibered asbestos paper with a fine and uniform texture.

The paper weighs 27 lb per 100 sq yd and has a lengthwise tensile strength of 45 psi per 1-in. width. It is available in 0.008, 0.010 and 0.015-in. thicknesses and can be supplied in sheets, rolls or tapes in widths up to 40 in.

KEY NO. 616

Carbon-Graphite Has Improved Properties

A new grade of Graphitar carbon-graphite material is said to have better resistance to oxidation at high temperatures than previously available grades. Parts made of the improved material can be used in oxidizing atmospheres at tempera-

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TEC and TEC-Z

...How to choose between a soft solder and a brazing alloy

Handy & Harman provides *two* alloys that fit between "something stronger than the average soft solder but not as strong as a silver-brazing alloy." They are named TEC and TEC-Z and their flow points are intermediate between soft solders and silver-brazing alloys. Joints made by these alloys are strong in straight tension or shear. For instance, butt joints of cold-worked copper can be made having a tensile strength of about 25,000 psi. This is approximately 10,000 psi. more than can be obtained with tin-lead soft solders. TEC joints retain their strength at elevated temperatures much better than the tin-lead soft solders. As shown in the table below, the strength of the solder itself at 425° F is about the same as a 50% tin–50% lead solder at room temperature in short-time tensile tests.

Applications – One example is a thermostatic bellows where the operating temperature is too high for soft solders (tin-lead), yet requires a joining medium which will not anneal the bellows. Another use is gun parts which require joint strength at higher than soft-solder operating temperatures *plus* corrosion resistance to solutions used in cleaning and blackening. Also for lamp bulb bases operating at approximately 350°-500° F. Automotive applications and heat exchangers. TEC conforms to Government Specifications Mil-S-19234 (Nord); both TEC and TEC-Z are available in sheet, wire, powder, and preforms to specifications.

NOMINAL COMPOSITIONS

	TEC	TEC-Z
Silver	5% plus or minus 0.5%	5% plus or minus 0.5%
Zinc		16.6% plus or minus 0.5%
Cadmium	95% plus or minus 0.5%	78.4% plus or minus 0.5%

PHYSICAL PROPERTIES

	TEC	TEC-Z
Color	White	White
Melting Point	640° F	480° F
Flow Point	740° F	600° F
Density (Troy oz/cu in.)	4.60	4.53
Electrical Conductivity (Cu=100)	22.0%	20.6%
Electrical Resistivity (Microhm-cm)	7.9	8.4

STRENGTH COMPARISON TEC vs. Pb-SN

	TENSILE STRENGTH LBS/SQ IN. TEC	TENSILE STRENGTH LBS/SQ IN. Pb-SN
ROOM	16,400	2,500
300° F	4,400	650
425° F	2,600	Melts
500° F	1,700	

The information and data on this page are available in our Handy Alloy Data Sheet. Ask for "TEC." Handy & Harman, 82 Fulton Street, N.Y.C. 38.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

Offices and Plants: Bridgeport, Conn. • Chicago, Ill. • Cleveland, Ohio • Dallas, Texas • Detroit, Mich. • Los Angeles, Calif. • New York, N.Y. Providence, R. I.. • Montreal, Canada • Toronto, Canada

DISTRIBUTORS IN PRINCIPAL CITIES

For more information, turn to Reader Service card, circle No. 382

DON'T OVERLOOK CARBON/GRAPHITE!

No Other Material Can Do ANY of These:

- Withstand immersion in water from 4,000°F without cracking.
- Resist surface atmospheric action while retaining constant and reproducible contact resistance.
- Be readily processed to provide low friction (graphite) or high friction (carbon) or any desired intermediate value.
- Withstand electric arcing in contacts, lightning arresters and similar applications without appreciable dimensional changes.
- Serve as an electrical conductor which is readily machinable and can operate satisfactorily up to 6,000°F.

No Other Material Can Do ALL of These:

- Resist corrosive action of most gases and chemicals.
- Serve as a semi-permanent, readily-formed mold for casting metals or glass.
- Act as a seal ring around a moving shaft to retain liquids and gases.
- Operate as a sliding contact on commutators and slip rings.
- Serve as a bearing material for vacuum applications or as an insert in ordinary bearings.
- Operate as a friction unit in constant-speed clutches.
- Serve as a non-welding contact, either by itself or in combination with other metals.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE

"EVERYTHING IN CARBON BUT DIAMONDS"

SEAL RINGS • BEARINGS • ROCKET NOZZLES • ELECTROCHEMICAL CELL ANODES • FLUXING TUBES • BRAZING BOATS & TRAYS • CATHODIC PROTECTION ANODES • RISER RODS • VOLTAGE REGULATOR DISCS • ELECTRICAL CONTACTS • HEATING ELEMENTS & ELECTRODES • TUBE ANODES • BRAZING TIPS • RUN-OUT TABLE SLABS • MOTOR & GENERATOR BRUSHES • FRICTION SEGMENTS • PUMP VANES • POROUS CARBON . . . and many more.

For more information, turn to Reader Service card, circle No. 358

What's new IN MATERIALS

tures up to 1200 F; most carbon-graphite grades begin to oxidize and lose weight at 700 F when heated in an oxidizing atmosphere.

The new material, identified as Grade 2573, is available from United States Graphite Co., Div. of Wickes Corp., Saginaw, Mich.

The producer says the material has a lower coefficient of friction, better wear resistance and greater stability than other grades of carbon-graphite. It can be formed into intricate shapes, ground to tolerances of 0.005 in. or less, and lapped and polished to within a few millionths of an inch. The material, lighter than magnesium and harder than many steels, is chemically inert and self-lubricating.

The improved carbon-graphite material is recommended for use as seals, bearings, end plates, valves, liners, bushings and similar parts.

KEY NO. 617

Stripping Compounds Remove Epoxy Resins

Two new stripping compounds attack and remove epoxy, polyester and similar materials. One compound is designed for removing uncured epoxy and polyester resins and the other is designed for removing cured epoxy resins. Both compounds are available from Metachem Resins Corp., 530 Wellington Ave., Cranston 10, R. I.

1. Compound for uncured resins

The stripping compound for uncured resins is said to effectively cut, dissolve and remove uncured epoxy resins, polyesters, greases, oils, inks and similar materials from equipment, bench tops and hands. The compound, which is supplied in gel form, makes the residue mixture water-miscible. It has a flash point of 190 F and an ignition temperature of 290 F. The compound is called Meta-Terge 1405 and it sells for 75¢ per lb in drum lots.

KEY NO. 618

2. Compound for cured resins

The other new stripping compound, called Meta-Strip 702, is noncorrosive and can be used to recover electronic parts that have been coated, cast or molded in epoxy or polyester resins. The compound is

The new generation of U.S. autos fends off corrosion . . .

GUARDED BY GALVANIZED STEEL

Use of galvanized steel sheets in the automotive industry has increased by more than 700% since 1954—and more automotive applications are on the way.

As a result of this growing addition to Detroit's diet, both consumers and manufacturers are benefiting. To car owners, every pound of galvanized steel means more complete corrosion protection, added durability and savings in maintenance. To manufacturers, galvanized steel's simplified fabricating procedures bring reduced costs. Head and tail lamp housings, for instance, formerly required five or six steps when zinc plated or painted after stamping. Now they are moved direct from press to assembly line with their tight zinc coatings completely undamaged by fabrication. This also applies to side members, rocker panels, front and rear rails and cross members.

WEIRKOTE, IN PARTICULAR! One of the leading galvanized steels, Weirkote is widely used in the latest model automobiles. To the inherent strength, economy and versatility of steel, Weirkote adds enduring zinc protection via the modern continuous process. As a result, it can be worked to the very limits of the steel base without chipping or peeling. And it assures you long-lasting protection against corrosion. It is manufactured by two National Steel divisions, Weirton Steel Company and Midwest Steel Corporation. Write Weirton Steel Company, Weirton, West Virginia, for further Weirkote details.

MIDWEST STEEL
Portage, Indiana

WEIRTON STEEL
Weirton, West Virginia

divisions of
NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 320

Make SHALLOW Measurements ACCURATELY

Wilson Rockwell Superficial Hardness Tester

• Wilson Rockwell Superficial hardness testers are used to measure surface hardness, coatings, thin metal or thin hard cases. The hardness test is based on a penetration of less than .005", and Wilson Superficial testers have the precision and ease of operation to give accurate readings every time.

Accurate—Precision-built for consistently correct results. Knife-edge bearings provide near-frictionless operation.

Easy to operate—Controls conveniently grouped—oil dash-pot system provides smooth load application.

Long lasting—Simple design, rugged construction make Wilson Superficial testers as durable as a machine tool.

Complete line available—Wilson Rockwell hardness testers and accessories are available in a wide variety for every hardness testing function.

Wilson "Brale" Diamond Penetrators Each diamond is cut to an exact shape. A comparator check and microscopic inspection of each diamond assure perfect readings every time.

Write for details—Ask for Catalog RT-58. It gives complete information on the Superficial tester as well as on the full line of Wilson Rockwell hardness testers.

WILSON "ROCKWELL" HARDNESS TESTERS

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-E Park Avenue, New York 17, New York

ACCO

For more information, turn to Reader Service card, circle No. 332

available in two forms: a liquid for soaking, and a thixotropic gel for painting large surface areas. The stripping compound sells for about $1.30 per lb in drum lots. It has a flash point of 150 F and an ignition temperature of 830 F.

The producer says Meta-Strip 702 should be used in a well ventilated area, and direct contact with the skin or breathing of vapors should be avoided. **KEY NO. 619**

Seamless Tubing Resists Hot Acids

Seamless small diameter tubing made from Ni-O-Nel, a nickel-iron-chromium alloy, is said to have good resistance to hot sulfuric, sulfurous, phosphoric and nitric acid solutions.

The producer, Superior Tube Co., 1548 Germantown Ave., Norristown, Pa., says the tubing should find use in the chemical, petroleum, mining, food and pharmaceutical processing industries in the form of heating coils, piping, heat exchangers and spray pipes. Sizes range from 0.012 to 1.125 in. o.d. with walls from 0.0015 to 0.125 in.

The Ni-O-Nel alloy used is made by International Nickel Co.

KEY NO. 620

Electrical Tapes Resist Fire, Cold Weather

Two new electrical tapes have been placed on the market recently. One is a pressure-sensitive plastics tape for low temperature applications; the other is a pressure-sensitive aluminum foil tape that is said to have good resistance to fire.

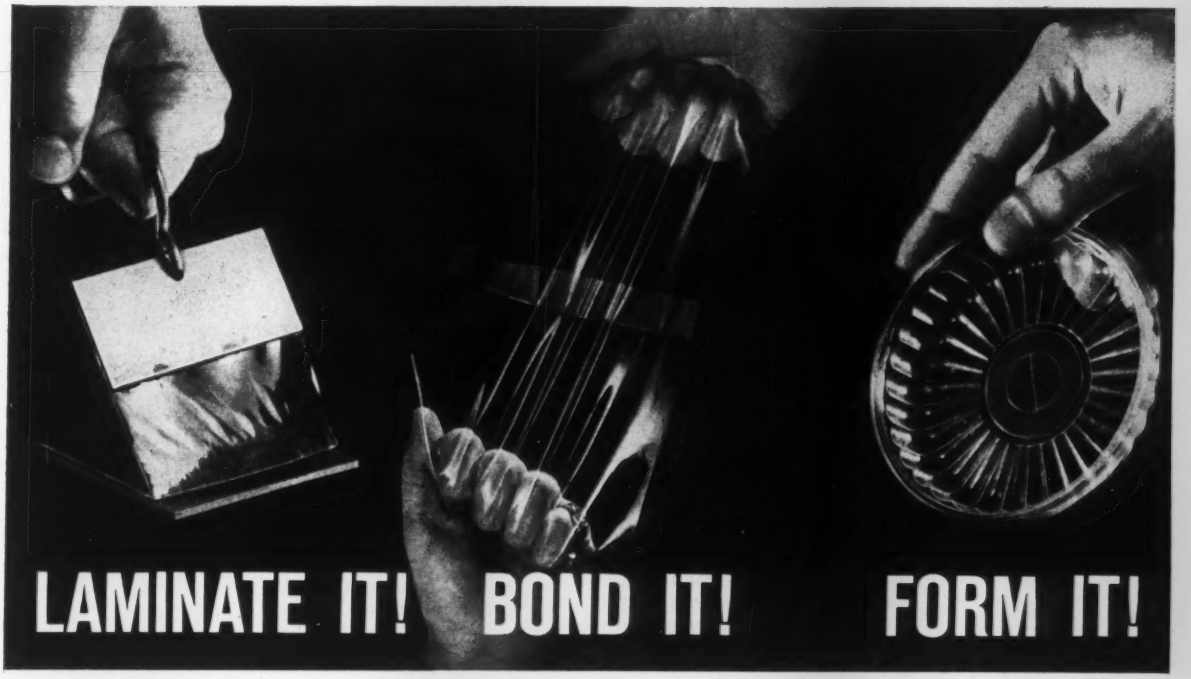
1. Low temperature tape

The low temperature plastics tape is said to remain flexible at temperatures down to –50 F. It was developed by Permacel, Inc., New Brunswick, N. J. and is called No. 295. The black plastics tape can be used outdoors under cold weather conditions or indoors in cold storage rooms and freezer plants.

The tape has high elongation and tensile strength, and good electrical properties. Although designed for cold weather use, the tape performs satisfactorily at temperatures up to

NEW FROM DU PONT...
a thermoplastic "Teflon" film that's easy to fabricate

TEFLON® FEP FILM



New "TEFLON"* FEP-fluorocarbon film has nearly *all* the unique advantages of "TEFLON" TFE with one big plus. It's a true thermoplastic that can be easily formed and sealed. One type of this new film can be applied *with* adhesives, another can be laminated and heat-bonded *without* them.

Here are just some of the advantages of "TEFLON" you get in this new film • Unique antistick and low-friction properties • Chemically inert to practically all known chemicals • Electricals are high (up to 4,000 volts/mil dielectric strength) and *stay* high • Performance stays virtually constant from –250°C. to over 200°C.

"TEFLON" FEP film opens the door to whole new areas of design and product improvement. Mail coupon and start investigating "TEFLON" FEP film for yourself. (Briefly describe the end use you have in mind.)

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E. I. du Pont de Nemours & Co. (Inc.)
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Wilmington 98, Delaware

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Company Name_____
Address_____
_____
Job Function_____
Proposed End Use_____

For more information, turn to Reader Service card, circle No. 438

MEEHANITE® MEANS BETTER CASTINGS

By W. H. MOORE
Vice President
Meehanite Metal Corp.

What you should know about Meehanite Metal

WHY THERE IS NO EQUIVALENT

How many times have you been told "I can give you something just as good as Meehanite® and at a lower price" only to find that the castings did not meet your standard of quality.

Actually there is no equivalent for Meehanite metal. Here's why: The exclusive Meehanite process makes use of 32 patented procedures that are essential to the production of highest quality castings and which can be used only by bonafide Meehanite licensees. These procedures relate to all phases of manufacture including processing agents, melting furnaces, sand control, and molding to insure the integrity exhibited by every Meehanite casting. More than 200 Meehanite foundries throughout the world prove the validity of these techniques and share in 35 years of technological know-how that truly puts Meehanite metal in a class by itself.

The production of Meehanite® involves a lengthy training period under the direction of Meehanite engineers, and a continuing program of metallurgical help and advice. Set standards of operation enable Meehanite foundry-men to apply structural control to castings on a day by day basis.

Essentially, the metallurgical control in the production of Meehanite castings involves obtaining a balance between undercooling produced in the melting operation and nucleation produced by processing the molten metal with alkaline earth agents. The initial degree of undercooling is related to the mass of the casting to be poured and the density and physical properties required. This is then modified by nucleation to force deposition of graphite at exactly the right time during solidification so as to give the right size and shape and distribution to the free graphite at the same time maintaining the character of the metallic matrix. The net result is predictable properties and uniform structure in every section of a casting and from casting to casting.

Gray cast iron made to a chemical specification without benefit of controlled undercooling is influenced by mass effect to a maximum degree and for this and other reasons cannot be considered an equivalent to Meehanite.

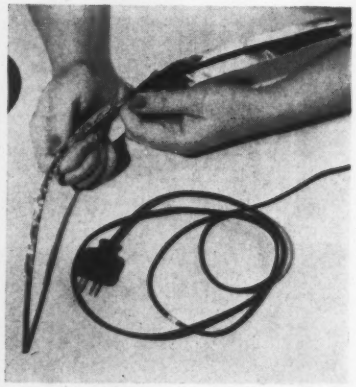
There are more than 26 different types of Meehanite metal available, each of which is specifically designed for a given set of service and conditions.

Accept no substitute for Meehanite quality and performance. Specify Meehanite castings and be sure. For more information about Meehanite castings and the foundries making them, write to: *Meehanite Metal Corporation, 714 North Avenue, New Rochelle, New York.*

MEEHANITE METAL

Meehanite Castings Are Made Only By Meehanite Foundries

For more information, turn to Reader Service card, circle No. 325



Mystik Adhesive Products, Inc.

***Aluminum foil tape** is said to provide a time saving and economical way for shielding lead wire from heat and electronic interference.*

180 F. It is supplied in a variety of sizes and packages. KEY NO. 621

2. Fire resistant tape

The aluminum foil tape was introduced by Mystik Adhesive Products, Inc., 2635 N. Kildare Ave., Chicago 39 and is called No. 7452. It consists of a 2-mil-thick backing of aluminum foil and a rubber-resin adhesive. The tape is said to have good fire resistance because the adhesive is covered with noninflammable aluminum foil.

The pressure sensitive tape can be used in any sealing, binding or holding application where extremely high heat is not encountered. Potential applications include shielding and grounding in electrical and electronic devices. The tape can also be used to seal hot and cold ducts, and to form a barrier against moisture vapor. KEY NO. 622

Phenolic Compound

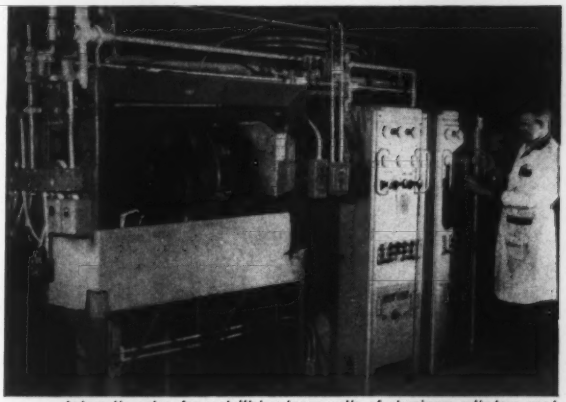
A high temperature molding material is designed for critical insulation and structural applications such as connectors, cams, gears and coil forms. The material, called RX 600, was developed by Rogers Corp., Rogers, Conn.

The material is a glass-reinforced phenolic that is said to have excellent electrical properties in the presence of moisture. It is also said

ENGINEER'S NOTEBOOK

Flame sprayed metal increases wear resistance better than 10 times

AIDS WEIGHT REDUCTION



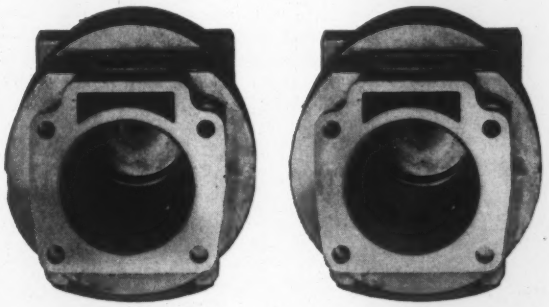
Automatic setup for metallizing inner walls of aluminum cylinders used in lightweight gasoline engines. Cabinet in foreground houses six-station rotary setup; automatic control panels are at right.

Many methods, including cast-iron cylinder liners and chrome plating, have been tested for wear resistance in lightweight gasoline engine blocks of aluminum.

Best of these methods experienced breakdowns in less than 400 hours. Now they are metallized with METCO Sprabond (molybdenum alloy) as a bonding agent, followed by a coating of sprayed steel alloy.

Test runs of over 4,000 hours show little or no wear of the metallized surface. Finish thickness is .007"; weight – a few grams. Cast-iron liners weighed almost ½ pound.

Cylinder at left machined ready for flame spraying; one at right has been metallized and hone finished.



Closeup of automatic six-station rotary setup. Cylinders are individually rotated at 150 rpm. Cylinder is loaded on table at Station 1, moved through Stations 2 and 3 for pre-heating by torch. At Station 4, bonding coat is applied by the gun nozzle which feeds into the rotating cylinder. Low alloy steel is applied at Station 5 and cylinder cools at Station 6. Cylinder walls are finished by honing.

New engineering data bulletin

Bulletin 136B—The METCO Flame Spraying Processes, provides basic engineering and application data on flame sprayed coatings of metals, ceramics, carbides and other high melting point materials. 16 pages. Send coupon for free copy.

METCO INC.
FORMERLY METALLIZING ENGINEERING CO., INC.
Flame Spray Equipment and Supplies
1175 Prospect Ave., Westbury, Long Island, N.Y.
Telephone: Edgewood 4-1300 Cable: METCO
In Great Britain: METCO, LTD.
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Don Watson
Please send Bulletin 136B.

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address

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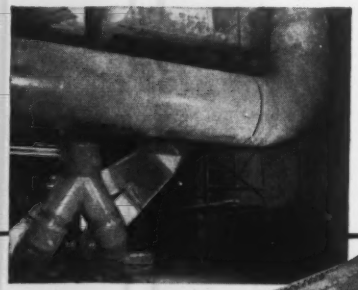
corrosion resistant **DURACOR**

replaces costly metal fabrications

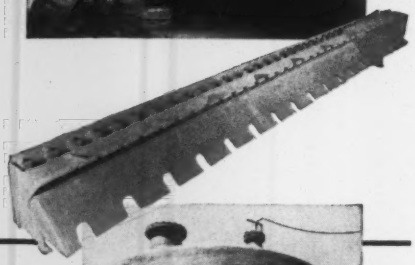
in the
METALWORKING
industry

Ceilcote engineers complete ventilating systems, gas scrubbing towers, hoods, tank covers, ducts, recovery tanks and other custom-ized fabrications.



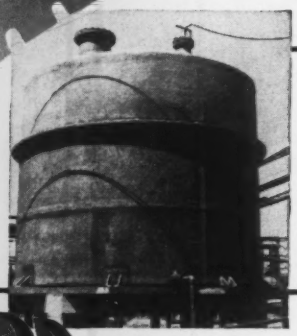
in the
TEXTILE
industry

Complex rayon spin machines, feed pipes, filters, screens, tanks and similar equipment are fabricated from Duracor.



in the
PETROLEUM
industry

Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.



in the
CHEMICAL
industry

Duracor is used extensively for special processing equipment, processing tanks, laboratory sinks, brine tanks, acid storage tanks, covers and ventilating systems.

PHYSICAL PROPERTIES

Tensile Strength p.s.i.: 11,000-15,000

Flexural Strength p.s.i.: 20,000-30,000

Tensile Modulus of Elasticity p.s.i.: 1.2—1.4 x 10^6

Flexural Modulus of Elasticity p.s.i.: 0.78—1.6 x 10^6

Impact Izod, Notched ft.-lbs./in.: 30—40

Specific Gravity: 1.4

Coefficient of Linear Expansion: 9.5 x 10^{-6} in./in./°F.

Standard Color: Light Green/Gray

Maximum Temperature (Exposure): To 500°F.

Save up to 40% over costly metal structures with Duracor processing equipment and ventilating systems! A product of Ceilcote's 33 years of corrosionproofing experience, Duracor combines extreme chemical resistance and high strength with light weight, heat and flame resistance. WRITE TODAY FOR VISUAL STANDARDS AND INDUSTRY SPECIFICATIONS!

THE CEILCOTE COMPANY, inc.
4899 Ridge Road • Cleveland 9, Ohio

DURACOR CEILCOTE

8595-CO

For more information, turn to Reader Service card, circle No. 433

to have good heat and flame resistance, and good dimensional stability.

The developer says the compound molds at extremely low pressures and can be used without difficulty in all types of automatic equipment.

KEY NO. 623

Conductive Black Ink for Printed Circuits

A new conductive ink for printed circuits has been developed by Advance Process Supply Co., Inc., 2315 W. Huron St., Chicago 12.

The material is described as a smooth, heavy-bodied black ink that screens sharply and dries in 30 to 45 min. Called No. R-284-V, the ink adheres well to a wide variety of materials.

The conductive ink is supplied in pint, quart and gallon containers.

KEY NO. 624

Two Epoxies Are Self-Extinguishing

Two new self-extinguishing epoxy resins have been introduced recently by Dow Chemical Co., Midland, Mich. Both resins are made self-extinguishing by substituting bromine on the epoxy molecule. They are cured or hardened with common epoxy curing agents.

According to Dow, self-extinguishing epoxy resins should find use in laminated aircraft structures, glass and paper-base laminated electrical circuits, filled castings, and in aircraft and missile adhesives. Marine paints and coatings for solid or foamed plastics are other likely uses.

No. X-3442 is a semisolid containing about 49% bromine. It can be used in blends with conventional liquid epoxy resins. Price is $1.25 per lb in truckload lots.

No. X-3441.1 is a solid resin containing about 19% bromine. It can be used either alone or in blends with conventional solid resins. Price is $1 per lb in truckload lots.

Dow says that physical and electrical properties of castings and laminates made with the new resins are comparable to properties developed by conventional epoxy resins,

Pumping liquid oxygen for guided-missile fueling at Patrick A.F.B., Florida. Air Products, Inc., a pioneer in the production of LOX and other cryogenic materials, ships liquefied gases in these tank-trailers lined with nickel stainless steel. Piping and supports are also made of nickel stainless steel for high strength at cryogenic temperatures plus low thermal conductivity.

Handling liquid oxygen at 297°F below zero...

. . . Nickel-containing steels retain toughness and strength where other materials become brittle.

These highway tankers haul tonnage quantities of liquid oxygen for missile fueling.

In the nation's steel mills, where vast volumes of oxygen are used to speed up steelmaking, liquid oxygen (LOX) is stored in giant tanks right at the mill.

Ever since oxygen was first liquefied, one of the biggest problems has been to develop materials that will store and handle it *safely*.

LOX is handled at −297°F. Even before you reach that point, liquid mercury becomes so hard you can use it for a hammer, and many materials become brittle and shatter like glass when struck.

But today alloys are available—nickel stainless and other nickel steels—to provide the properties needed for low-temperature work.

Because these steels remain strong and tough at sub-zero temperatures, they are well suited to serve at temperatures where other metals embrittle and fracture. In short, they offer the most economical—and the safest—means to build anything from a liquid-helium generator to an ocean-going tanker for shipping liquefied gases.

If you are active in low-temperature chemistry or physics . . . or if you store or transport liquefied gases in small or large quantities . . . there is exactly the right nickel alloy steel to help you solve your problems.

For comprehensive data on steels for sub-zero service, we invite you to write for a copy of the new booklet, "Steels for the Containment of Liquefied Gas Cargoes." It's yours for the asking.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

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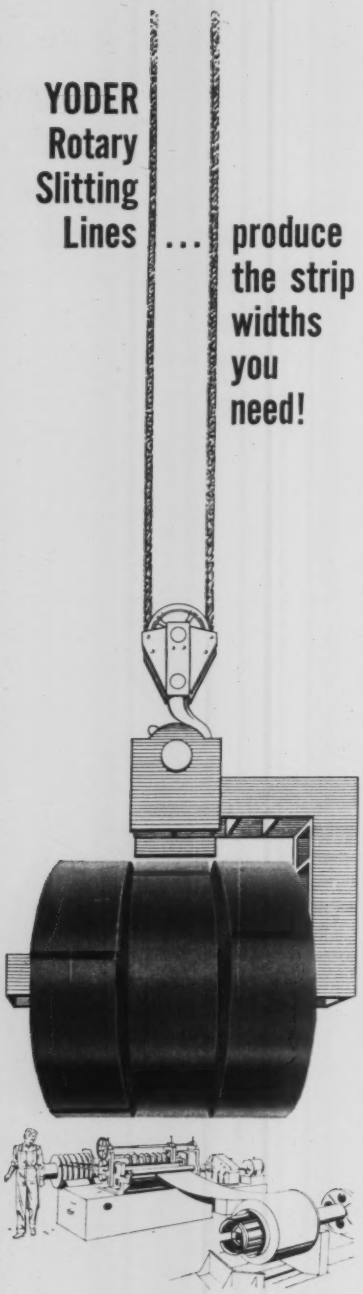
YODER Rotary Slitting Lines ... produce the strip widths you need!



Investigate the many advantages of YODER-engineered Slitter Installations. Write today for the comprehensive, 80 page YODER Slitter Manual ... it's yours for the asking!

THE YODER COMPANY
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1910 FIFTY YEARS 1960

ENGINEERING YODER MANUFACTURING ROTARY SLITTING LINES

For more information, circle No. 364

except that modulus properties are reduced at 300 F.

Prepregs made with either of the self-extinguishing resins are said to meet physical and electrical properties as set forth in NEMA G-11 specification, except for 300 F flexural strength. KEY NO. 625

Nickel Powder Strip Has High Purity

High purity nickel strip continuously rolled from powder is now a production item at Metals for Electronics, Inc., 1331 Dixwell Ave., Hamden 14, Conn. Up to now, rolling of metal powders into strip has been limited for the most part to laboratory and pilot plant work.

Big feature of the new strip is its high purity: it averages 99.9% nickel, with carbon, sulfur and oxide contents held to very low levels. As a result, the strip is expected to find wide use in electronic and other applications where high purity material is required. The strip is supplied in coil form in thicknesses up to 0.025 in. Details as to how it is produced have not been disclosed.

A comprehensive report on the status of metal powder rolling was given in the Aug '59 issue of this magazine (p 136). KEY NO. 626

Porous Ceramic Brick Withstands 4200 F

A zirconium oxide type of ceramic brick withstands temperatures up to 4200 F and is promising for use as a thermal insulation in nuclear reactors, space vehicles, and vacuum and other types of furnaces.

Designated No. 4200, the material was developed by Ipsen Industries, Inc., P. O. Box 500, Rockford, Ill. Current production is on a laboratory basis. The material is being

PROPERTIES OF NO. 4200 CERAMIC

Melting Point, F	4620
Ther Cond (2200 F), Btu/hr/sq ft/°F/in.	<1.0
Specific Heat, Btu/lb/°F	0.175
Coef of Ther Exp (70-2700 F), per °F	5.7×10^{-6}
Weight (2½ by 4½ by 9 in. brick), lb	2.2
Porosity, %	89

SCOTT MODEL LGP PRESSURE AGING OVEN

Featuring 14 small-volume, seamless pressure cylinders encased in a solid aluminum block . . . the Scott Model LGP sets a new standard of *safety* and *cleanliness* for pressure aging tests of rubber, silicone and other elastomers.

The Model LGP uses no liquid heating medium — no danger of oil fires or explosions, no need for costly protective barricades. Each pressure cylinder has precise-seating cap, separate purging valve, and *blowout disc* for fast, safe release of excess pressure.

No Contamination — Individual pressure stop cocks permit examination and removal of test specimen without disturbing conditions in other pressure cylinders. Positively no migration or contamination from one pressure cylinder to another! All stainless steel construction (except blowout discs) eliminates metal contamination of test material.

Easy Operation — Slight hand pressure opens or closes pressure cylinder cap. Thermo-control switch and suitable insulation assure exact, uniform temperatures. Also, has over-riding thermo-switch for double protection. Scott automatic temperature recorders are also available to guarantee conformance with ASTM Methods of Test D-572 and D-454.

Write for complete facts on Scott safety-designed Model LGP. Scott Testers, Inc., 65 Blackstone Street, Providence, Rhode Island. Tel: DExter 1-5650 (Area Code 401).

SCOTT TESTERS
THE SURE TEST ... SCOTT!

For more information, circle No. 416

a Reminder

to those who use chemical nickel alloy plating:

There is only ONE

Kanigen®

and 29 patents prove it

There are no substitutes for Kanigen—no other process that applies a hard, corrosion-resistant nickel alloy coating without the use of electricity as Kanigen does.

With Kanigen, you can plate anything from a small relief valve to a 20,000 gallon tank car with a virtually non-porous, uniform coating.

How can you be sure of getting Kanigen? Only one way—by calling General American or one of its licensees. For further information write:

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1421 Park Avenue
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KEYSTONE CHROMIUM CORPORATION
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KEYSTONE METAL FINISHERS, INC.
22 Raydol Avenue
Secaucus, New Jersey

For more information, turn to Reader Service card, circle No. 375

MATED PARTS help new pen

another wonderful GRC idea for designers

8 tiny parts die cast & molded by GRC for Esterbrook . . . precision "mated" to solve the intricate parts problem posed by new-type ballpoint pen

GRC molded 6 tiny parts in nylon and die cast 2 in zinc alloy to form the foundation of the new rotating mechanism evolved by Esterbrook engineers. The uniformity and accuracy of GRC's unique automatic single cavity die casting and molding methods made possible the precision mating of tiny parts . . . eliminated the necessity of selective assembly . . . assured trouble-free operation of the assembled pen . . . and again provided a new dimension to designers faced with a difficult situation.

Write for detailed bulletins or send prints for quotation. Quick deliveries on quantities of 25,000 to millions.

NO SIZE TOO SMALL!
Maximum size
Zinc Alloy
½ oz. 1¾",
Plastic
.03 oz. 1¼".

25 years of progress in tiny parts

GRIES REPRODUCER CORP.
World's Foremost Producer of Small Die Castings
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ON THE JOB EVERYWHERE IN INDUSTRY . . .

BUSADA BUTYRATE TUBING

TRANSPARENT—COLORLESS

Consistently high quality . . . Clear . . . durable . . . economical. ¾" to 8½" O.D. 6 ft. and 20 ft. lengths, ¼" thickness.

BUSADA BUTYRATE PIPE AND FITTINGS
First choice of many of the nation's leading firms because it's easier to install, easier to inspect, won't corrode . . . speeds liquid flow.

BEFORE YOU BUY GET BUSADA'S QUOTATION

Busada Manufacturing Corporation

32-19 Downing St., Flushing 54, New York, N. Y., LEnox 9-3431

For more information, turn to Reader Service card, circle No. 417

formed in the standard brick size of 2½ by 4½ by 9 in.

The new material has a cellular structure consisting of uniform open pores with all cells interconnected. The cellular structure is said to permit the passage of gases for purging and evacuation. The porous brick also permits the passage of liquids.

The ceramic brick has a temperature limit (hot face) of 4200 F under vacuum conditions and in oxidizing atmospheres. It has a temperature limit of 3000 F in a reducing atmosphere with carbon present, and 2200 F when in contact with silicon carbide. **KEY NO. 627**

TFE Powder Used to Lubricate Wood, Metals

Powdered TFE resin is being sold under the name Poly-Powder for use as a dry lubricant on wood, metals, rubber, plastics, leather, glass and other materials. It is available from Polydoris Products Corp., 5306 W. Lawrence Ave., Chicago 30.

According to the producer, the lubricant is odorless, tasteless and nonstaining. It is said to have the lowest coefficient of friction of all solid materials: 0.016 to 0.024 against polished steel.

The powder can be added to lacquer and paints for low friction coatings and to liquid and grease-type lubricants to increase lubricity. **KEY NO. 628**

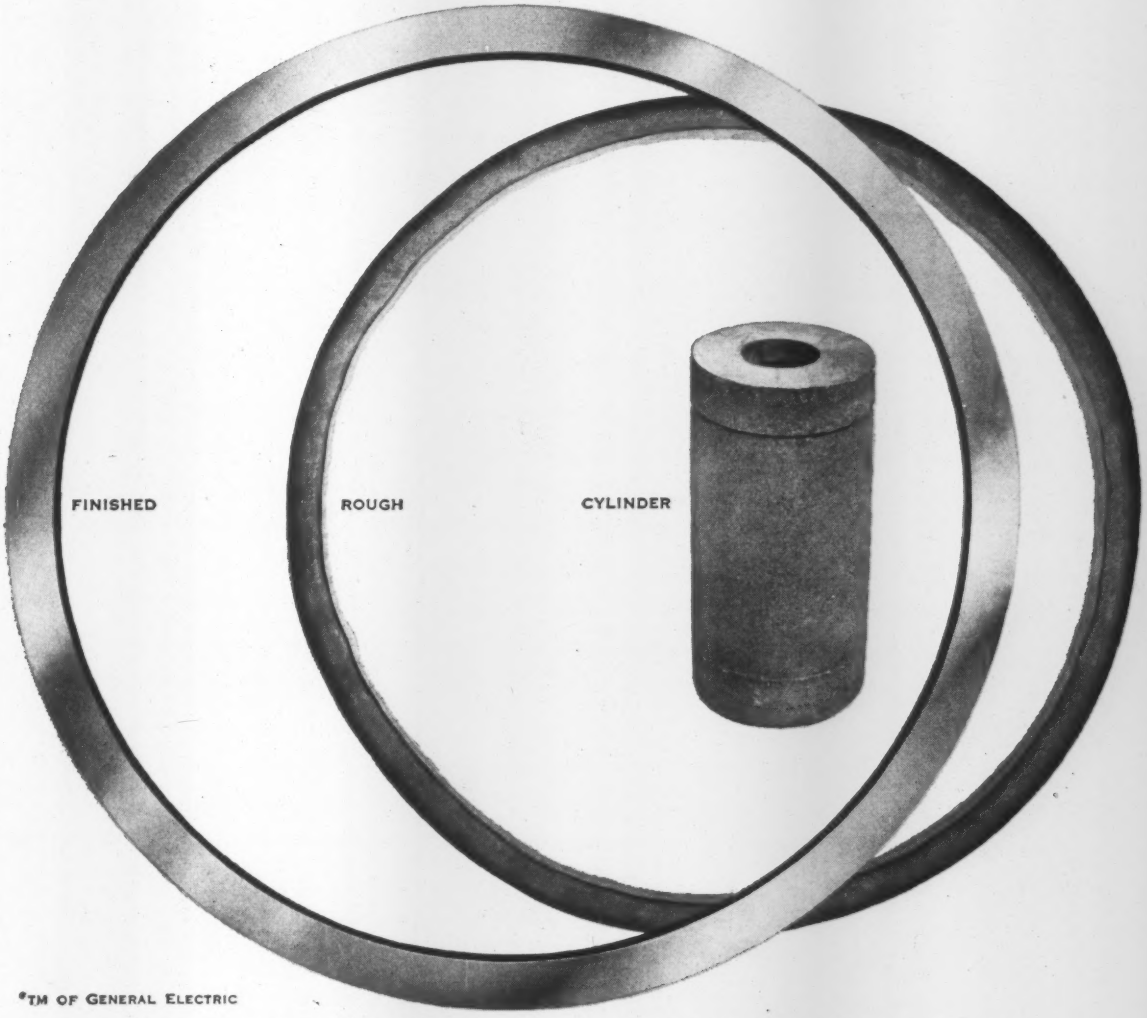
New Structural Steel Is Strong, Easy-to-Use

A stronger, easier to use and more economical structural steel for bridges, buildings, ships, pressure vessels and other applications has been developed in Canada. According to C. C. Weeks, vice president-sales, Algoma Steel Corp., Sault Ste. Marie, Ontario, Canada, the new grade of steel has official specification approval by the Canadian Standards Assn. Mr. Weeks says that Algoma Steel Corp. is now producing plates, bars and structural shapes to the new specification.

The new grade of structural steel has a guaranteed minimum yield

NOW—A WELD-FREE RENÉ 41* RING DEVELOPED BY C-M TO ELIMINATE THE PROBLEMS OF WELDED RINGS.

C-M'S RENÉ 41 RING IS FORGED FROM A CYLINDRICAL CASTING INSTEAD OF ROLLED FROM BAR STOCK AND WELDED. THIS INTEGRAL, WELD-FREE RENÉ 41 RING IS THE RESULT OF A CASTING PROCESS DEVELOPED BY C-M USING A THIN CROSS-SECTION RATHER THAN THE CONVENTIONAL THICK INGOT. BECAUSE THE CROSS-SECTION IS THINNER, IT COOLS QUICKER. THIS FAST COOLING PREVENTS SEGREGATION OF ELEMENTS—ELIMINATES STRINGERS. GRAIN SIZE IS MORE UNIFORM, TOO, AND THE RING HAS GREATER HOMOGENEITY THAN RINGS PRODUCED BY OTHER METHODS.



*TM OF GENERAL ELECTRIC

C-M'S PROCESS CAN HELP SOLVE YOUR RING PROBLEMS ON RENÉ 41 AND OTHER DIFFICULT-TO-FORGE IRON, NICKEL AND COBALT ALLOYS. WRITE TODAY FOR COMPLETE INFORMATION.

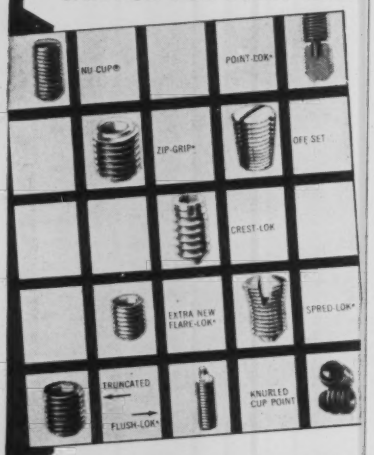
ULTRAMET VACUUM ALLOYS

CANNON-MUSKEGON CORPORATION

METALLURGICAL SPECIALISTS • 2873 LINCOLN STREET • MUSKEGON, MICHIGAN

For more information, turn to Reader Service card, circle No. 355

SETKO
self-locking set screws
WIN FOR YOU EVERY TIME!



ONE OF THESE NUMBERS COULD BE YOUR WINNING ANSWER TO:

- **Increased product reliability**
- **Lower costs**
- **More dependable performance**

Whatever your requirements demand — better holding power, resistance to vibration, ease of application, etc.—chances are you'll find the *right* answer among the many types of self-locking set screws made by Setko. Many of the styles illustrated here can be combined with various head styles, points or locking actions to give you a set screw that will fit your *specific needs best,* at the lowest cost.

Why not join the hundreds of companies who have been winning lower costs and better product performance with the exclusive holding characteristics of Setko self-locking set screws?

SEND FOR FREE SELECTOR CHART AND TEST SAMPLES!

Exclusive Setko self-locking set screws selector chart lists over 1,001 possible combinations. Write for your copy and test samples.

SETKO Set Screw & Mfg. Co.

Send us your specifications for Free Engineering recommendations.

149 Main Street, Bartlett, Illinois

® Pat. 2,778,265 *Pat. Applied for 822

We specialize in solving puzzling screw problems!

For more information, circle No. 326

What's new IN MATERIALS

strength of 40,000 psi for thicknesses up to ⅝ in. This compares with a yield strength of 33,000 psi for G40.4, the old specification, and 36,000 psi for A36, the recently released ASTM specification.

The steel was originally developed to combat brittle failure in steel structures; as a result it shows improved toughness at low temperatures. The steel, composition of which has not been disclosed, is also said to have good weldability.

KEY NO. 629

Urethane Products for Insulating, Sealing

Two new urethane foam products have been introduced recently for insulating and sealing applications.

1. Urethane insulation

A urethane foam insulation marketed by American Cellular Co., Inc., New Castle Del. is designed for insulating pipes over the temperature range –300 to 275 F. The insulation, called Thermax, is constructed with a longitudinal seam so that it can be spread open to receive a pipe.

KEY NO. 630

2. Urethane seal

Sterling Alderfer Co., 3850 Granger Rd., Akron 13, Ohio has developed a process (details not revealed) in which continuous lengths of urethane foam can be made in round and half-round shapes. The shapes, called Foamedge, can be supplied slit or channeled. They are recommended for sealing, vibration dampening and soundproofing applications.

KEY NO. 631

Polyurethane Sealant Is Tough, Long Lasting

A new polyurethane sealant is expected to last several times as long as conventional oil-base compounds which have an effective life of one to three years in outdoor applications. The material has maintained excellent adhesion and resilience after five years of outdoor exposure, showing no signs of erosion, hardening, shrinking or wrinkling.

The sealant is called No. 829-901 Black U.I. and is available at

6061-T6 ALUMINUM

Phoenixspun®

FROM

2" THICK PLATE

and CONTOUR MACHINED TO SPACE AGE TOLERANCES

Do you have similar jobs?

Thicknesses up to 2" and diameters up to 170" are readily PHOENIXSPUN from high strength aluminum alloys, titanium, and exotic metals. Tolerances of plus or minus .005" are accurately maintained with this radically new and exclusive, heavy duty, powerspinning equipment. A wide range of conventional spinning requirements can also be produced economically by the various PHOENIX Metal Processing methods. If your metal forming project involves outer space, electronic, nuclear or general industrial products contact us at once.

Write for information and new brochure.

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PHOENIX PRODUCTS COMPANY
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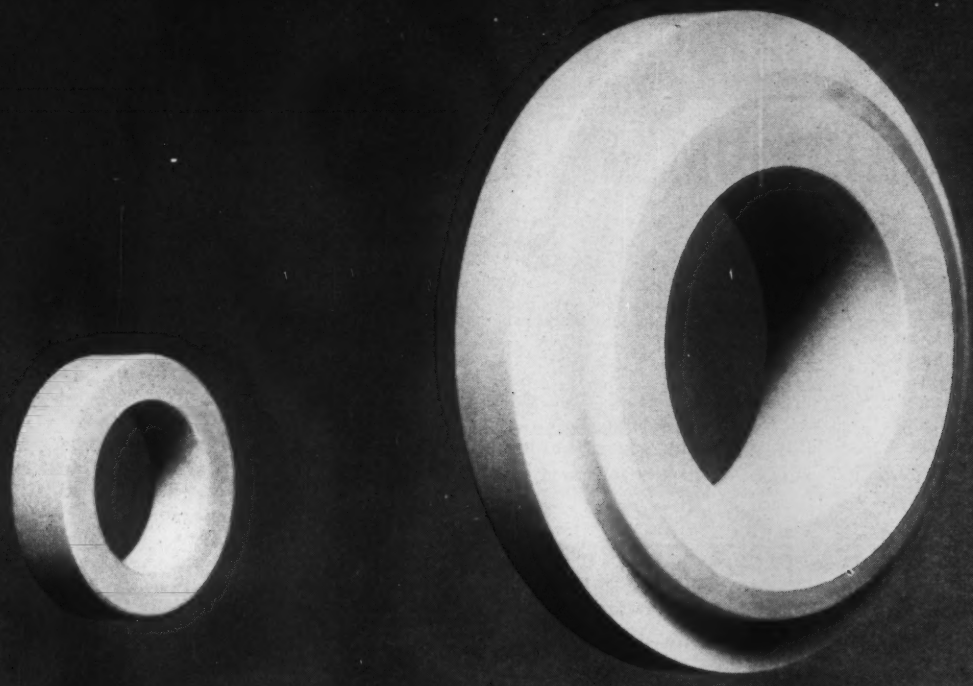
For more information, circle No. 437



Tractors or Reactors

From tractor water pumps to atomic reactors, Coors Ceramic has proved itself to be an ideal material for mechanical shaft seal rings. From workaday to space age applications...the extreme resistance to abrasion and corrosion of this material offers long, trouble-free service life. Coors Ceramic is also used where price is a factor, as in dish washers and other appliances. Write for Design Data Sheet 5002 for a complete story of Coors Ceramic in seal rings. Or call your nearest Coors Regional Sales Manager: WEST COAST, *William S. Smith, Jr., EM 6-8129, Redwood City, Calif.;* MIDWEST, *John E. Marozeck, FR 2-7100, Chicago, Ill.;* CENTRAL, *Donald Dobbins, GL 4-9638, Canton, Ohio;* EAST COAST, *John J. McManus, MA 7-3996, Manhasset, N. Y.;* NEW ENGLAND, WARREN *G. McDonald, FR 4-0663, Schenectady, N. Y.;* SOUTHWEST, *Kenneth R. Lundy, DA 7-5716, Dallas, Texas;* OIL FIELD INDUSTRY, *William H. Ramsey, UN 4-6369, Houston, Texas.*

Coors

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Coors Porcelain Company

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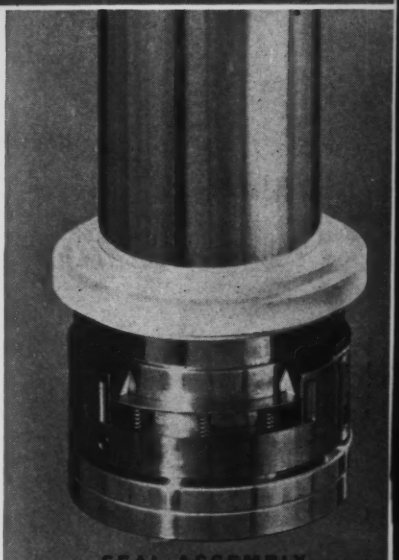

SEAL ASSEMBLY CUT AWAY

For more information, turn to Reader Service card, circle No. 366

Solid Platinum Anode Performance at 1/10th the Cost

PLATANIUM® ANODES

PLATANIUM ANODES, made from titanium mesh coated with a uniform thickness of platinum by the PLATANEX* Plating Process, are equal functionally to solid platinum anodes yet cost less than 1/10th as much.

Thanks to a unique diamond configuration design, PLATANIUM ANODES give maximum anode area while cutting down over-all size 50% or more.

PLATANIUM ANODES are recommended for a wide range of electrolytic operations—from electroplating to refining or chemical processing—wherever insoluble anodes are indicated.

We're in full production and can offer immediate shipment of PLATANIUM ANODES in practically any size or quantity required.

Our technical bulletin PLT-1 gives details and price information.

*Trademark, patent applied for.

Sel-Rex **SEL-REX CORPORATION**
NUTLEY 10, NEW JERSEY

The world's largest selling precious metal electroplating processes

For more information, turn to Reader Service card, circle No. 394

DELRIN* and **LEXAN®**

ROD and **SLAB**

For Prompt Delivery!

Write for Complete Literature

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DISTRIBUTORS FROM COAST TO COAST

Member of Plastic Pioneers

*Du Pont Trademark
® Reg. TM G.E. Co.

For more information, turn to Reader Service card, circle No. 345

$21.50 per gal from E. I. du Pont de Nemours & Co., Inc., Fabrics and Finishes Dept., Wilmington 98, Del.

Sealant is easy to apply

The material is a soft, high modulus composition that is easily applied with either a calking gun or a knife. It comes in a single package, requires no field mixing or curing accelerators, and does not shrink on aging. Other advantages claimed for the sealant are:

1. Its adhesive properties are not adversely affected by significant changes in temperature over the range –165 to 300 F.

2. It will not slump or sag in vertical or overhead installations in joints as wide as ¾ in.

3. It has excellent resistance to water, and is inert to most chemicals, solvents and corrosive atmospheres.

The film-forming urethanes in the sealant provide a tough skin in 1 to 3 days, and the material is completely cured to a durable, elastic rubber in 10 to 14 days.

KEY NO. 632

Other News . . .

Metals

▸ A new aluminum-coated steel wire is available in limited quantities from National-Standard Co., Niles, Mich. The wire, called Alstan, is made by what is described as an exclusive process, details of which have not been revealed. The wire is expected to be used in the communications field. **KEY NO. 633**

Plastics

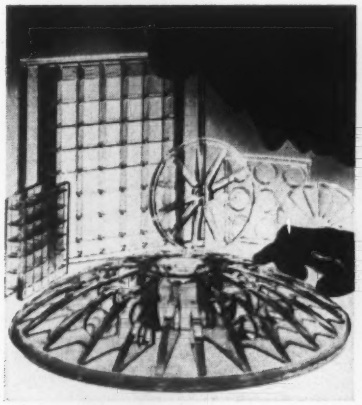
▸ A two-package polyether foaming system for the production of rigid urethane foams is available from Pittsburgh Plate Glass Co.'s Paint Div., 1 Gateway Center, Pittsburgh 22. Known as Selectrofoam 6504-6505, the system contains all necessary chemical additives, and eliminates the need for any additional formulating before using.

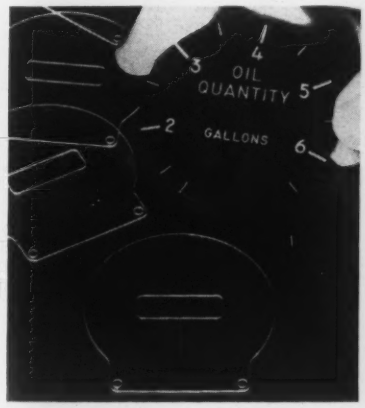
KEY NO. 634

▸ What is claimed to be the first phenolic varnish to produce a flame retardant, high electrical grade laminate with excellent cold punching properties has been announced by Monsanto Chemical Co.'s Plastics Div., Springfield, Mass. The new

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING





99.999+% PURE FUSED SILICA

Astronomers are notoriously strict about materials. Well they might be, since a minor deviation in an optical material makes for catastrophic miscalculations when extrapolated through the infinity of space.

A new fused silica which we developed is eliciting quiet approval, the most anyone expects, from the meticulous astronomer. Drop to the molecular level and you will find only several parts of impurity per million of silica.

Such purity is naturally beneficial to the optical properties of the material. It has an extremely high degree of optical homogeneity. When you talk visible or ultraviolet light, it is the most transparent glass we have ever made. On the physical side, it has a coefficient of expansion of 5.6×10^{-7}/°C. Its refractive index is n_D-1.4584. Birefringence constant: 3.40 m mu/cm/kg/cm². Neither gamma nor X-rays darken it.

Among some of the various products that we have made or are presently working on are telescope mirrors up to 80 inches, ultrasonic delay lines; windows for wind tunnels, high temperature viewing and star guidance systems.

We can play a few tricks with this fused silica in designing. Witness the unique sandwich construction of the mirror blanks above. This simple design innovation cuts as much as 50% off the weight of the mirror blanks without sacrificing rigidity one whit.

The coupon is your invitation to get more information on this new Corning material.

WILL THE MACHINE GIVE WAY TO CHEMICALS?

The dial faces shown above right were made without the assistance of a single die or jig, without grinding or cutting or drilling or milling or stamping or any other mechanical operation.

We made them by exposing photosensitive glass to a precisely drawn pattern and a series of chemical etchants.

This is more than a parlor trick.

It is a method of making parts precisely which would be impossible or far too costly to make mechanically. It is the FOTOFORM® process.

We make brush holders for digital computers which call for rectangular holes measuring 0.0075″ x 0.015″.

We can take a square inch and riddle it with as many as 250,000 holes, each precisely like all its neighbors. Or, with a simple inexpensive change in art work, we could make just one of those 250,000 holes a triangle.

The material itself is nonporous and dimensionally stable glass, utterly free of flaws and voids and able to operate continuously at 500°C.

We can use the same process on FOTOCERAM,® one of our glass-ceramics which has a coefficient of expansion nudging zero.

If you would like to know more about chemical machining and the photosensitive glasses, please send the coupon.

FOR 10^{-6}mm Hg GREASELESSLY

With all due apologies to the people who make grease, it *is* usually a nuisance in vacuum lines.

It's also a likely source of contamination.

So, we say, get rid of grease.

There are recesses in the sockets of this joint which match to perfection the configuration and dimensions of a Buna-N O-ring.

Even without grease, this seal will hold a vacuum down as far as 10^{-6} without leaking.

The assembly accepts a standard socket and clamp.

The glass is PYREX® brand No. 7740, so it will not serve as a source of contamination either. It's easily worked to fit into any setup, so it should be in demand for more than the usual bench-top vacuum line. There should be considerable demand among people everywhere who want a tight, greaseless joint.

The November 1959 issue of *The Review of Scientific Instruments* has something to say about this useful new tool. So do we. For our message, call your local lab supply dealer, or send us the coupon direct.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS, 5002 Crystal St., Corning, N. Y.

Please send information on:

☐ Fused silica ☐ FOTOFORM ☐ O-ring vacuum joint

Name..... Title.....

Company.....

Street.....

City..... Zone..... State.....

For more information, turn to Reader Service card, circle No. 323

material is called Resinox 495. Paper-base laminates impregnated with the varnish are said to meet the electrical, physical and mechanical requirements of NEMA standards and Underwriters' Laboratory test for flame retardance. KEY NO. 648

▸ A lead-filled plastics sheet material for radiation protection has been developed by Crowl Chemical Corp., El Monte, Calif. The material is supplied in sizes up to 48 by 96 in. in various lead densities and gages. Sale of the material is handled by Charles Frost Associates, Downey, Calif. KEY NO. 635

▸ Liquid epoxy resins are now being marketed by Thiokol Chemical Corp., 780 N. Clinton Ave., Trenton 7, N. J. Trademarked Tipox, the resins can be used for chemical resistant coatings, dimensionally stable castings, and high strength structural adhesives. KEY NO. 636

Other nonmetallics

▸ A transparent plastic, dry-film rust preventive is designed especially for metal surfaces stored outdoors for long periods. The producer, E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, says the rust preventive is easy to apply and remove. Called Rust Veto 342, it will not crack or flow over the temperature range –40 to 175 F. KEY NO. 637

▸ Surf-Kote L-1020 is the name of a new dry film lubricant designed for high temperature, high pressure applications. The lubricant contains a modified molybdenum disulfide compound and additives suspended in a synthetic resin base vehicle. It is available from Hohman Plating & Mfg. Co., 814 Vermont Ave., Dayton 4, Ohio. KEY NO. 638

▸ A new line of aluminum oxide ceramic parts is now available from Duramic Products, Inc., 426 Commercial Ave., Palisades Park, N. J. The parts are custom fabricated and are said to have good heat resistance (up to 3000 F), good electrical properties and high strength. KEY NO. 639

▸ Two new silicone materials have been designed for use as washes for ingot molds in the steel industry. One material, a silicone emulsion for application to hot molds, is designated XM-2020. The other material, XS-4017, is a solution of silicone in a fire resistant, volatile carrier and can be used on both hot and cold molds. The two materials are available from General Electric Co., Silicone Products Dept., Waterford, N. Y. KEY NO. 640

Finishes

▸ An acrylic-base paint resin has been introduced by Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio. Enamel, semigloss, flat and clear coatings based on the new resin (Pliolite AC) are said to hold up exceptionally well against acids, alkalis and various types of oils. KEY NO. 641

▸ A new primer, P-289, has been announced by John L. Armitage & Co., 245 Thomas St., Newark 5, N. J. It has been developed specifically for use with plastisols, organosols and textured vinyl finishes. The producer says the primer adheres well to steel, aluminum, galvanized metals, glass and other materials. KEY NO. 642

▸ Lamart Corp., 16 Richmond St., Clifton, N. J. is selling its line of checkered polyester laminates in six new metallized patterns. Each pattern can be laminated to vinyl, cotton or latex-impregnated paper. KEY NO. 643

Joining and fastening

▸ An improved adhesive system for bonding silicone rubber to itself and to other materials has been introduced by Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. The thermal-curing adhesive, called Cohrlastic C-251, can be used over the temperature range –100 to 500 F. KEY NO. 644

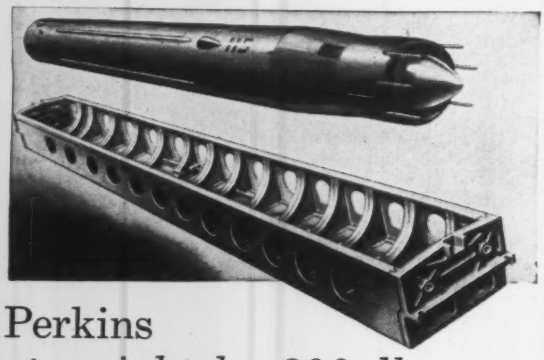
▸ A new series of bolts is said to have 39% greater tensile strength and 54% higher stress rupture strength than current elevated temperature bolting used in the 900-1200 F temperature range. The bolts, designated EWB 1218, are available from Standard Pressed Steel Co., Jenkintown, Pa. KEY NO. 645

Adhesives

▸ A new two-part epoxy adhesive has been introduced by Hysol Corp., Olean, N. Y. for bonding aluminum honeycomb panels, ferrous metals, ceramics and glass. The adhesive is said to have a peel strength of 63.3 in-lb on aluminum to aluminum. It is called No. 10-001. KEY NO. 646

Heat treating

▸ A new electric furnace for bright annealing of stainless steel strip has been announced by General Electric Co., Schenectady 5, N. Y. The furnace uses a very pure and dry atmosphere of hydrogen or dissociated ammonia that prevents formation of scale on the strip. Thus, strip does not require passes through pickle baths to remove scale. KEY NO. 647



Missile tray made by Brooks & Perkins *beats target weight by 300 lbs.*

Air transported missiles require minimum weight handling equipment so that important defense weapons can be moved efficiently and on schedule. Recently, Brooks & Perkins was given the responsibility for engineering, designing, building the prototype and manufacturing an aluminum missile tray, shown above.

Unusual loading problems and the extreme importance of deflection required a dimensional tolerance of ± 1/32" in the 33-foot over-all length at 68°F. B & P not only met all tolerance requirements, but also reduced the initial target weight by 300 lbs.

The aluminum missile tray is another example of Brooks & Perkins skill and experience in the fabrication of light metal products for ground support equipment.

For more information and details of this and other GSE programs, write direct to Brooks & Perkins, Detroit.

BROOKS & PERKINS, Inc.
W. FORT ST., DETROIT 16, MICH.
1916 Offices in Washington and New York
60-T-7R

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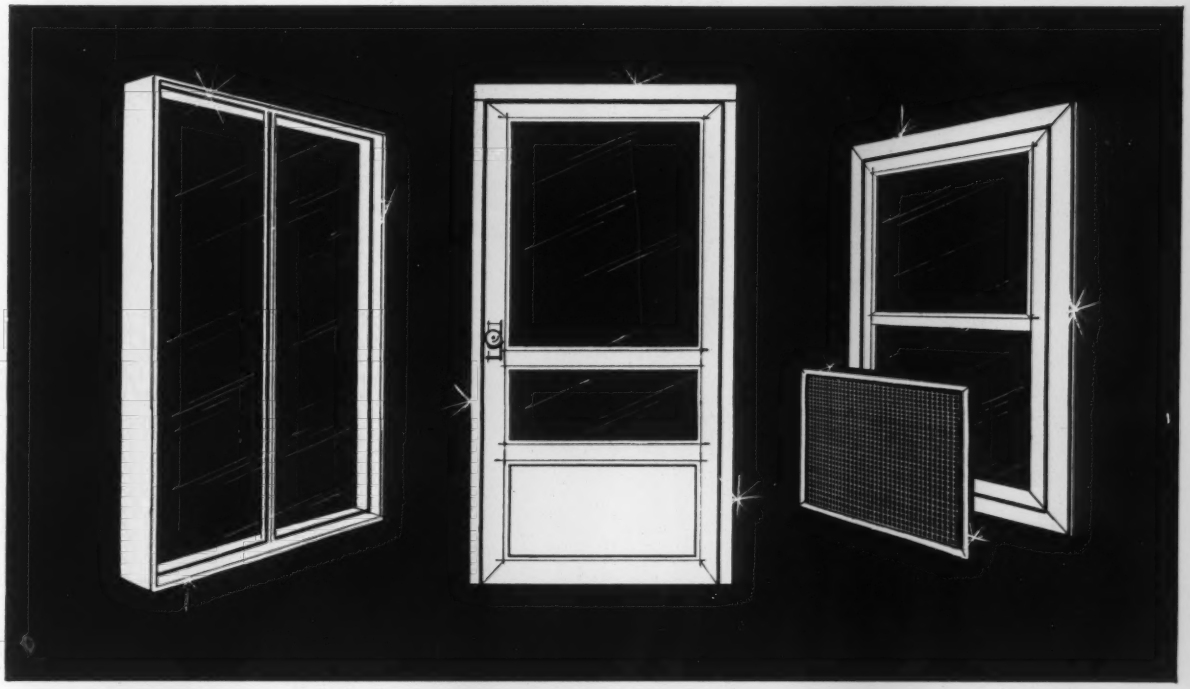


NOW... Colorless Protective BONDERITE Coating for Aluminum

BONDERITE 725 adds exceptional corrosion resistance to aluminum without changing the appearance of the metal!

This new Bonderite produces a *colorless*, amorphous oxide coating on aluminum without the use of electric current. In addition to imparting excellent corrosion resistance to aluminum, Bonderite 725 coatings are an excellent base for clear lacquer and paint finishes.

Colorless Bonderite 725 is particularly suited for use on aluminum building products, windows, storm and screen sash, doors, aircraft parts, automotive trim, boats, appliance parts, castings, and extrusions of all varieties.

Aluminum articles coated in Bonderite 725 and finished with clear lacquer easily meet the stringent requirements of the lime and mortar test specified for certain building products. In addition, articles finished in clear lacquer have good abrasion resistance that reduces scratches during handling and erection.

Bonderite 725 is an efficient, economical chemical treatment applied by spray or immersion application in simple processing equipment. Processing times are as low as 5 seconds.

Up-grade the quality of your products by supplying corrosion resisting Bonderized aluminum in its pleasing natural color. You can add this sales advantage to your product at a treatment cost that will please you.

For complete information now, call or write Parker, or use coupon below.

Parker
Rust Proof Company
2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base • BONDERITE and BONDERLUBE aids in cold forming of metals • PARCO COMPOUND rust resistant • PARCO LUBRITE—wear resistant for friction surfaces • TROPICAL—heavy duty maintenance paints since 1883

*Bonderite, Bonderized, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

Parker Rust Proof Company
2173 E. Milwaukee, Detroit 11, Michigan

Please send Bulletin which describes Colorless Bonderite for Aluminum.

Name_____

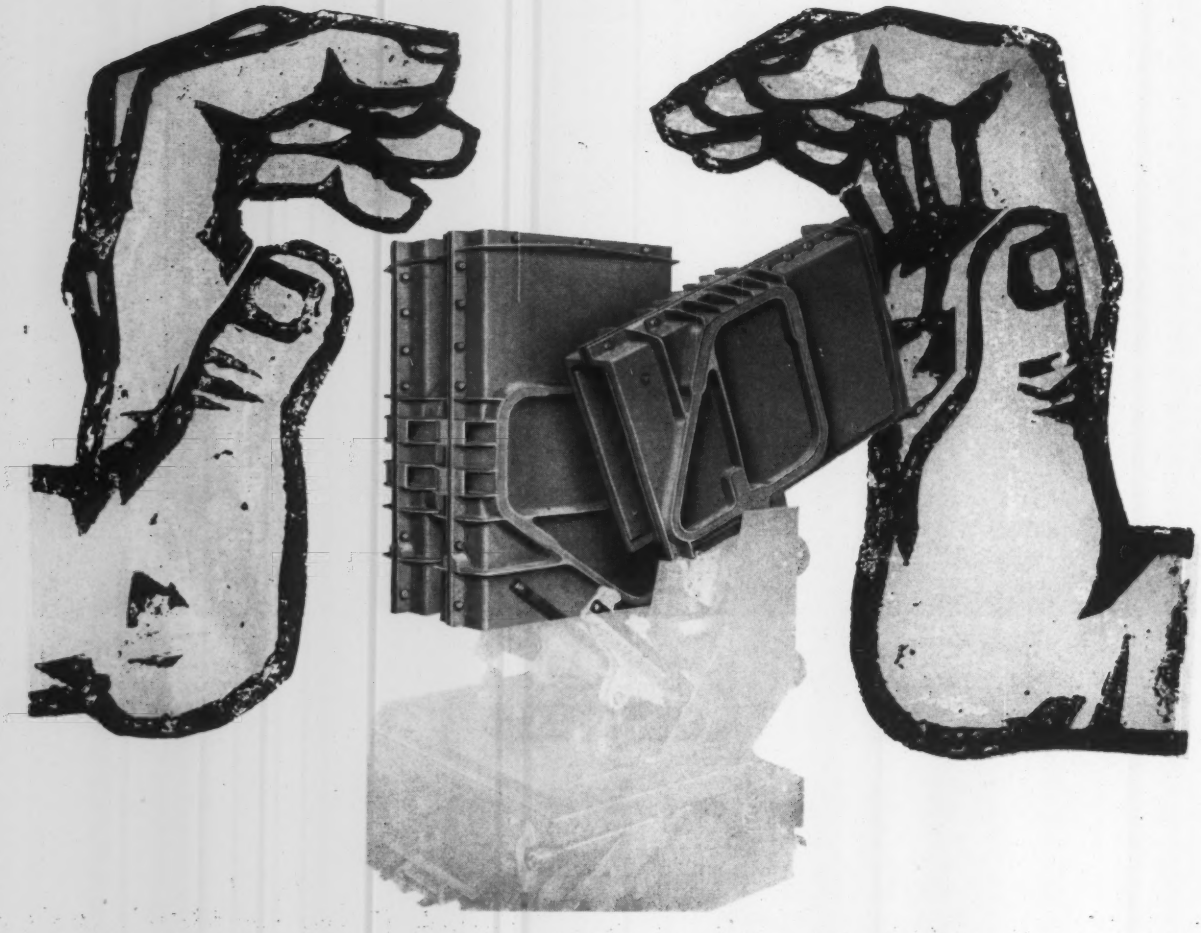
Title_____

Company_____

Address_____

City_____ Zone_____ State_____

For more information, turn to Reader Service card, circle No. 404



How to squeeze compact switchgear into still less space!

Throughout the electrical industry, they're talking about St. Regis® Panelyte's revolutionary new arc chute for I-T-E's latest switchgear. For, among other advantages, this chute helps make the switchgear approximately one-third smaller than the next most compact unit made.

Each chute is molded at 2,000 psi using a non-tracking, flame-retardant polyester-glass fiber molding compound. Molds are 24″ x 15″ x 2¼″ and must meet a minimum dielectric strength test of 250 volts/mil.

Special test molds—A *joint* Panelyte I-T-E development program was underway long before the first drawing. Panelyte engineers made special test molds to determine the optimum wall configuration for housing the chute's blowout coils. Then Panelyte engineers worked hand-in-hand with I-T-E to cut both overall chute size and unit cost.

Extensive Panelyte manufacturing facilities—When the switchgear's design was frozen, Panelyte's manufacturing group took over. Using special presses, quality production was both fast and economical. Each molding was proof-tested to assure highest quality.

Why don't you take advantage of Panelyte's Customer-Supplier Development Program . . . and of Panelyte's 22 years' experience in high-pressure molding? For complete details on *all* the advantages Panelyte offers you, write today to Dept. MDE-261, Industrial Panelyte Division, St. Regis Paper Company, No. Enterprise Ave., Trenton, N. J.

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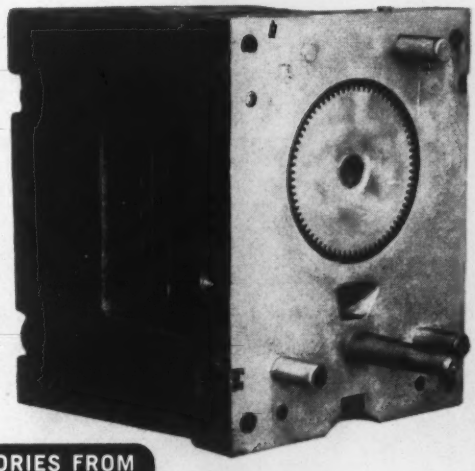

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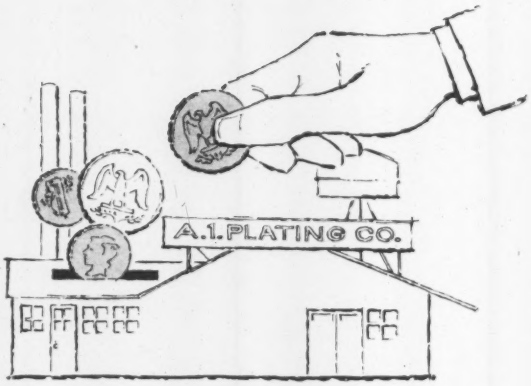

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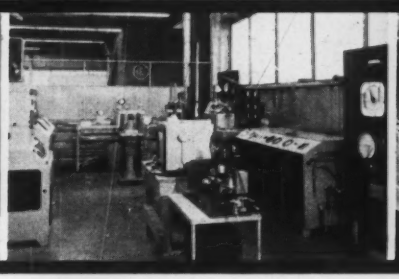

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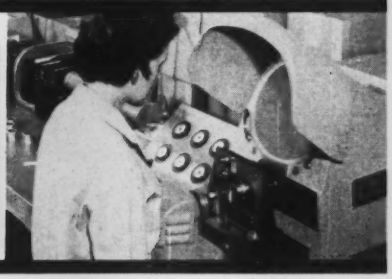

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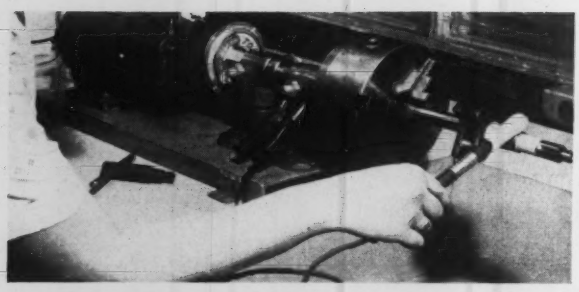

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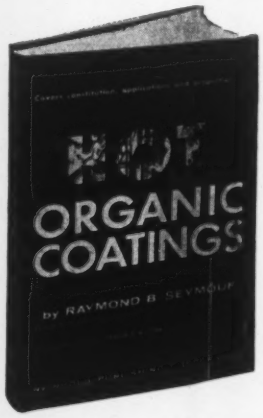

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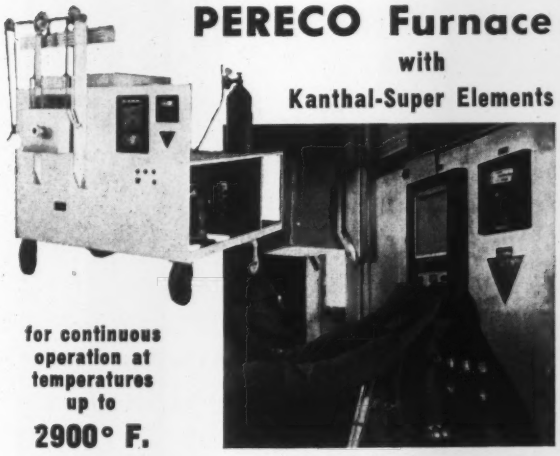

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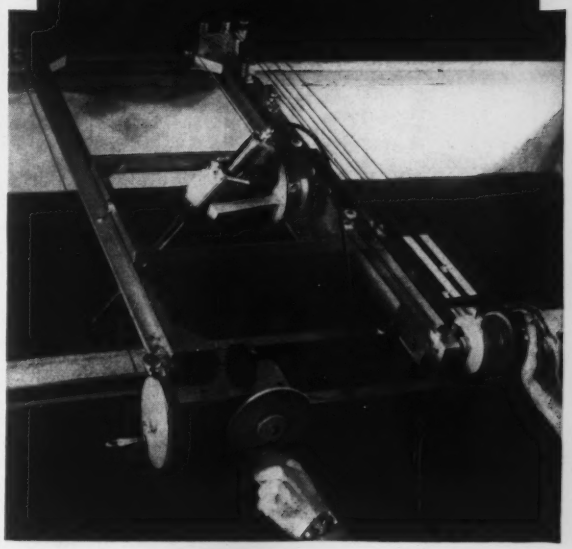

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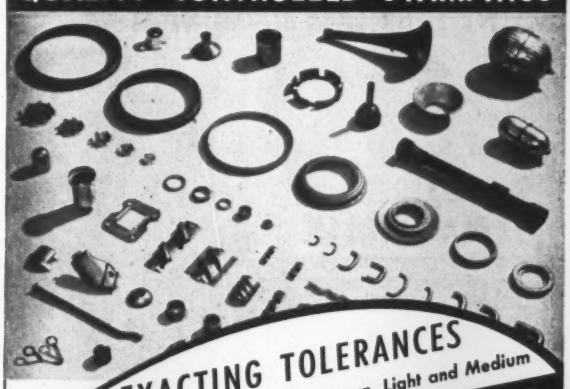

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For more complete information, and application data on their lines, refer to the index of Advertisers in the Mid-November MATERIALS SELECTOR ISSUE *of* MATERIALS IN DESIGN ENGINEERING.

THE LAST WORD

Dear Editor... I have a problem

(A composite of those letters to the editor that never get printed. No allusions to anyone living, dead, or nearly dead are intended.)

Dear Editor:

I want to write and thank you for the fine job you did with the article on "Materials Are Here to Stay—Why Not", which I think I saw in your fine magazine. I am ordering reprints, if you have them, to send to my friends. Although they can't read too well, this article will be an eye-opener, if there ever was one, and we need more of this kind of thing in this day and age when everything is going to pot in a hand basket.

But the other article on "What's New in Peanut Butter" was a bunch of rubbish, and you should know better than to print such twisted facts and distort the truth. I had the idea of packaging peanut butter in toothpaste tubes way back in 1909, but the big glass interests saw to it that my idea never saw the light of day.

I am a working engineer with four small children and a wife who works hard all day which she wouldn't have to do if other engineers would design things better instead of taking it easy with coffee breaks and long lunch hours and kidding around with the girls in the pool. When I got out of school I worked 15 hours a day, which is a long time to be on your feet and pushing a slide-rule around. It's this kind of thing that made America great and I think engineers should work seven days a week to keep it from going to pot, if necessary, which I said before, and stop drinking so much and living it up all the time on the expense account when they are on trips to Chicago where all the night clubs are.

And while I'm on the subject, I want to say that there are too many magazines, meetings, societies and dogs that scratch up your lawn after you work hard to get rid of all the crab grass. As long as we let people get away with this they will always take advantage of us.

Speaking of dogs, the crux of the problem is the Sales Dept. which never understands us engineers and promises the customer everything, which it knows we can't deliver to them. And since they don't know any better—I mean the customers, of course—they get mad and we lose them and then we get all the blame for something we did or didn't do, which is confusing to say the least.

But I think it should be clear to everybody who thinks about it that the trouble is that the top brass are always sticking their big noses into the engineering department which they don't know anything about and where they don't belong. It gets everybody nervous and makes the boss run around like a chicken with his head cut off. And that doesn't do anybody any good. So I think everybody would be better off if they would mind their own business and stop complaining and criticizing all the time.

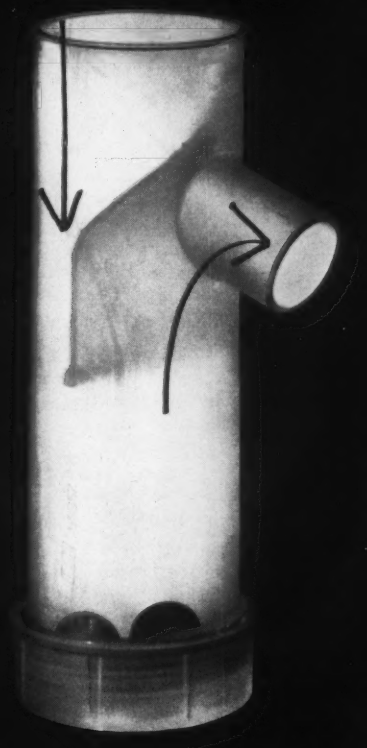
You can print this, but don't use my name, because as I said I have a wife and four children and two cats to feed, which isn't easy on $500 a week these days.

Very truly yours,
ANONYMOUSE

by H. R. Clauser
Editor

there are always good reasons for designing it in

polypropylene



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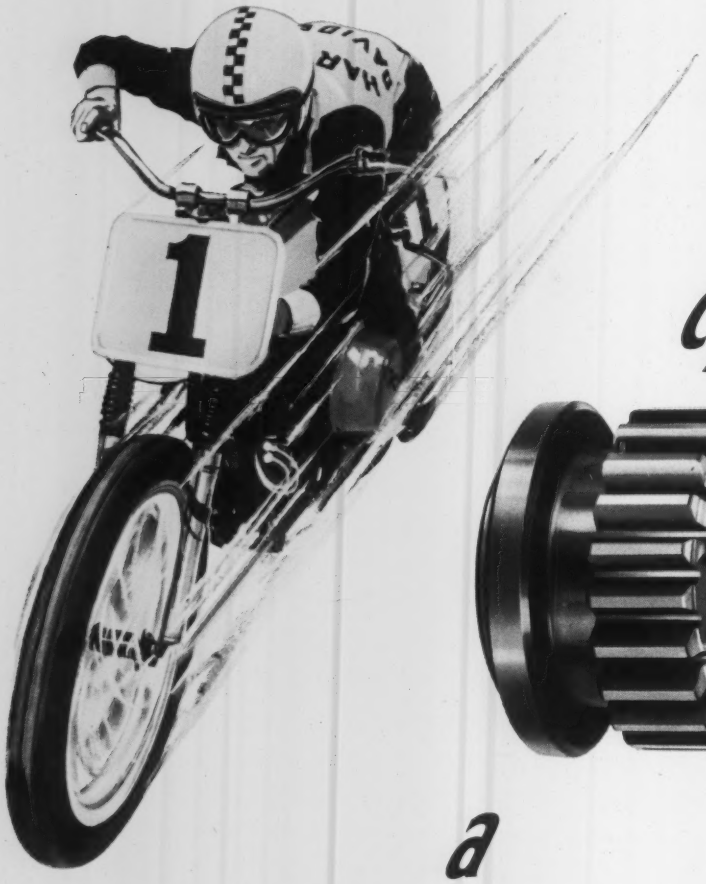

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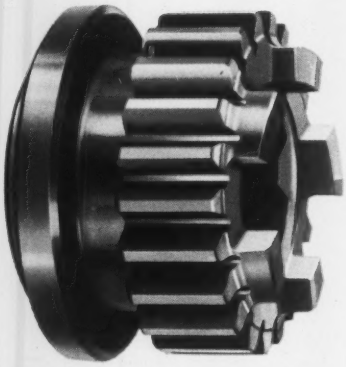

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